

NAME OF WORK :- CONSTRUCTION OF MAJOR BRIDGES ON ANKLESHWAR-RAJPIPLA ROAD (SH-64) UNDER HIGH SPEED CORRIDOR SCHEME (PHASE-1) DIST .BHARUCH IN THE STATE OF GUJARAT (W.S. (1) MAJOR BRIDGE NEAR UCHHALI AT CH 06+785 RHS (2) MAJOR BRIDGES ON KAVERI RIVER AT CH 14+720 LHS (3) MAJOR BRIDGE NEAR RANIPOR AT CH 23+180 LHS & RHS (4) MAJOR BRIDGE NEAR RAJPARDI AT CH 30+490 RHS.

TECHNICAL SPECIFICATIONS

For Schedule B

TECHNICAL SPECIFICATIONS

1.0 PREAMBLE:-

1.1 The Technical Specifications contained herein shall be read in conjunction with the other Bidding Documents as specified in this Volume.

1.2 Site Information:-

1.2.1 The information given here under provided elsewhere is given in good faith by the Employer but the Contractor shall satisfy himself regarding all aspects of site conditions and no claim will be entertained on the plea that the information supplied by the Employer is erroneous or insufficient.

2.0 GENERAL REQUIREMENTS:-

The technical specifications in accordance with which the entire work described herein after shall be constructed and completed by the Contractor shall comprise of the "SPECIFICATION"

2.1 The "SPECIFICATION" for each item is attached with tender is based on following.

(1) "SPECIFICATION FOR ROAD AND BRIDGE WORKS" (Fifth Revision printed in year 2013) issued by the Ministry of Road Transport & Highways (MORT & H), Government of India and Published by the Indian Roads Congress, hereinafter to as MORT & H Specifications.

(2) The General Technical Specifications for Road works.

(3) The General Technical Specifications for Bridge works.

Note:- (2) To (3) are Conventional Specifications Booklets usually attached for (R&B) Works.

2.2 If, a particular clause (which is incorporated in "SPECIFICATION") of specification booklets (1) to (3) above is Amended / Modified/ Added upon then the Amendment/ Modification/Addition shall supersede the relevant clause incorporated in "SPECIFICATION"

2.3 In, so far as Amended / Modified / Added Clause may come in conflict or be inconsistent with any of the provisions of the MORT & H Specifications under reference, the Amended/Modified/ Added Clause and the additional specifications shall always prevail.

2.4 In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the latest codes and specification, of IRC and BIS in that order. Where even these are silent, the construction and completion of the works shall conform to sound engineering practice as approved by the 'Engineer' and , in case of any dispute arising out of the interpretation of the above, the decision of the 'Engineer' shall be final and binding on the Contractor.

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ITEM WISE SPECIFICATION

Item No.1: Excavation for foundation in sand, gravel, clay soft soils and murrum etc. including shoring, strutting dewatering as necessary and disposing of the excavated stuff as directed.(A) Depth upto 3.0 M.

304.1. Scope

Excavation for structures shall consist of the removal of material for the construction of foundations for bridges, culverts, retaining walls, headwalls, cutoff walls, pipe culverts and other similar structures, in accordance with the requirements of these Specifications and the lines and dimensions shown on the drawings or as indicated by the Engineer, work shall include construction of the necessary cofferdams and cribs their subsequent removal; all necessary sheeting, shoring, bracing, and pumping; the removal of all logs, stumps, grubs and other matter and obstructions, necessary for placing the foundations; trimming bottoms of excavations; backfilling and clearing up the site the disposal of all surplus material.

304.2. Classification of Excavation

All materials involved in excavation shall be classified by the Engineer in the following manner:

(a) Soil

This shall comprise topsoil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose murrum, a mixture of these and similar material which yields 10 the ordinary application of pick, spade and/or shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having dimension in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

Authority for classification: The classification of excavation shall be decided by the Engineer and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Engineer.

304.3. Construction Operations

304.3.1. Setting out: After the site has been cleared according to Clause 201, the limits of excavation shall be set out true to lines, curves and slopes to Clause 301.3.1.

304.3.2. Excavation:

Excavation shall be taken to the width of the lowest step of the footing and the sides shall be left plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

The depth to which the excavation is to be carried out shall be as shown on the drawings, unless the type of material encountered is such as to require changes, in which case the depth shall be as ordered by the Engineer. Propping shall be undertaken when any foundation or stressed zone from an adjoining structure is within a line of 1 vertical to 2 horizontal from the bottom of the excavation.

Where blasting is to be resorted to, the same shall be carried out in accordance with Clause 302 and all precautions indicated therein observed. Where blasting is likely to endanger adjoining foundations or other structures, necessary precautions such as controlled blasting, providing rubber mat cover to prevent flying of debris etc. shall be taken to prevent any damage.

304.3.3. Dewatering and protection:

Normally, open foundations shall be laid dry. Where water is met with in excavation due to stream flow, seepage, springs, rain or other reasons, the Contractor shall take adequate measures such as bailing, pumping, constructing diversion channels, drainage channels, bunds, depression of water level by well-point system, cofferdams and other necessary works to keep the foundation trenches dry when so required and to protect the green concrete/masonry against damage by erosion or sudden rising of water level. The methods to be adopted in this regard and other details thereof shall be left to the choice of the Contractor but subject to approval of the Engineer. Approval of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

Where cofferdams are required, these shall be carried to adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for facilitating construction to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping equipment's, etc., inside the enclosed area.

If it is determined beforehand that the foundations cannot be laid dry or the situation is found that the percolation is too heavy for keeping the foundation dry, the foundation

concrete shall be laid under water by tremie pipe only. In case of flowing water or artesian springs, the flow shall be stopped or reduced as far as possible at the time of placing the concrete.

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping shall be permitted during the placing of concrete or for any period of at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall or other similar means.

At the discretion of the Contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the excavation area.

The Contractor shall take all precautions in diverting channels and in discharging the drained water as not to cause damage to the works, Crops or any other property.

304.3.4. Preparation of foundation:

The bottom of the foundation shall be levelled both longitudinally and transversely or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed. In the event of excavation having been deeper than that shown on the drawings or as otherwise ordered the Engineer, the extra depth shall be made up with concrete masonry of the foundation at the cost of the Contractor as per Clause 2104.1. Ordinary filling shall not be used for the purpose to bring the foundation to level.

When rock or other hard strata is encountered, it shall be freed of all soft and loose material, cleaned and cut to a firm surface either level and stepped as directed by the Engineer. All seams shall be denied out and filled with cement mortar or grout to the satisfaction of the Engineer. In the case of excavation in rock, annular space around footing shall be filled with lean concrete M15 upto the top level of rock.

If the depth of fill required is more than 1.5 m in soft rock or 0.6 m in hard rock above the foundation level, the filling upto this level shall be done with M-15 concrete and portion above shall be filled by concrete or by boulders grouted with cement.

When foundation piles are used, the excavation for pile cap shall be done after driving/casting of all piles forming the group. After pile driving operations in a given pit are completed, all loose and displaced materials therein shall be removed to the level of the bottom of the pile cap.

304.3.5. Slips and slip-outs: If there are any slips or slip-outs in the excavation, these shall be removed by the Contractor at his own cost.

304.3.6. Public safety: Near towns, villages and all frequented places, trenches and foundation pits shall be securely fenced, provided with proper caution signs and

marked with red lights at night to avoid accidents. The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures. For safety precautions, guidance may be taken from IS: 3764.

304.3.7. Backfilling: Backfilling shall be done with approved material after concrete or masonry is fully set and carried out in such a way as not to cause undue thrust on any part of the structure. All space between foundation masonry or concrete and the sides of excavation shall be refilled to the original surface in layers not exceeding 150 mm compacted thickness. The compaction shall be done with the help of suitable equipment such as trench compactor, mechanical tamper, rammer, plate vibrator etc., after necessary watering, so as to achieve the maximum dry density.

304.3.8. Disposal of surplus excavated materials: All the excavated materials shall either be reused with the approval of the Engineer or disposed off with all leads and lights as directed by the Engineer. Rates quoted by the Contractor deemed to include credit for usable material and salvage value of unusable materials. All the excavated materials shall be the property of the Employer. The material obtained from the excavation of roadway, shoulders, verges, drains, cross-drainage works etc., shall be used for filling up of (i) roadway embankment, (ii) the existing pits in the right-of-way and (iii) for landscaping of the road as directed by the Engineer, including levelling and spreading with all lifts and lead and no extra payment shall be made for the same.

All hard materials, such as, hard murrum, rubble, etc., not intended for use as above shall be stacked neatly on specified land as directed by the Engineer with all lifts

Unsuitable and surplus material not intended for use within the lead specified above shall also, if necessary, be transported with all lifts and lead and disposed of or used as directed by the Engineer.

304.4. Measurements for Payment

Excavation for structures shall be measured in **cu.m** for each class of material encountered, limited to the dimensions shown on the drawings or as directed by the Engineer. Excavation over increased width, cutting of slopes, production/support to the existing structures shoring, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid separately.

"The rate of Excavation for foundation shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

304.5. Rates

304.5.1. The Contract unit rate for the items of excavation for structures shall be payment in full for carrying out the required operations including full compensation for:

- (i) Setting out;

- (ii) transporting the excavated materials for use or disposal with all leads and lifts;
- (iii) construction of necessary cofferdams, cribs/sheeting, shoring and bracing and their subsequent removal;
- (iv) removal of all logs, stumps, grubs and other deleterious matter and obstructions, for placing the foundations including trimming of bottoms of excavations;
- (V) foundation sealing, dewatering including pumping when no separate provision for it is made in the Contract;
- (vi) Backfilling, clearing up the site and disposal of all surplus material within all lifts and leads or as otherwise specified; and
- (vii) All labour, materials, tools, equipment, safety measures, diversion of traffic and incidentals necessary to complete the work to Specification.

304.5.2. The Contract unit rate for preparation of rock foundation shall be full compensation for cutting, trimming and cleaning the foundation surface and filling/sealing of all seams with cement grout or mortar including all materials, labour and incidentals required for completing the work.

Item No.2:- Excavation for foundation in sand, gravel, clay soft soils and murrum etc. including shoring, strutting dewatering as necessary and disposing of the excavated stuff as directed.(A) Depth 3.0 M to 6.0 M.

This work shall consist of Providing shall be carried out as per relevant detailed specification of **Item No.1 for Excavation for foundation in sand** of this contract shall conform to relevant sections of these specifications.

"The rate of Excavation for foundation shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

The item shall be measured & paid as finished work in **Cum.**

Item No.3 :-Empty boring through all sorts of strata for providing 1.20 Mt. diameter R.C.C. bored piles to required depth required depth including providing necessary casing pipe with all plants and equipments as required complete.

Boring for 1.5m dia. R.C.C. bored piles shall be carried out using rotary or percussion type equipment. Unless otherwise approved by the Engineer, the diameter of the bore-holes shall be not more than the inside diameter of the liner.

A minimum of 2.0 m length of top of bore or the length as shown on the drawing shall invariably be provided with casing/liner to ensure against loose soil falling into the bore. In cases in which the side soil can fall into the hole, it is necessary to stabilize the side of the bore hole with drilling mud, or a suitable steel casing. The casing may be left in position permanently specially in cases where the aggressive action of the ground water is to be avoided, or in the case of piles built in water or in cases where significant length of piles could be exposed due to scour.

The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion after it and adjacent casings have been driven and driving core, if any, has been withdrawn.

For bored cast-in-situ piles, casing/ liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the length shown on the drawing or as approved by the Engineer. Materials inside the casing shall be removed progressively by air lift, grab or percussion equipment or other approved means.

Where bored cast-in-situ piles are used in soils liable to flow, the bottom of the casing shall be kept enough in advance of the boring tool to prevent the entry of soil into the casing, thus preventing the formation of cavities and settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level for the same reasons. The joints of the casing shall be made as tight as possible to minimize in flow of water or leakage of slurry during concreting.

The drilling mud such as bentonite suspension shall be maintained at a level sufficiently above the surrounding ground water level to ensure the stability of the strata which is being penetrated throughout the boring process until the pile has been concreted.

Where bentonite suspension is used to maintain the stability of the bore-hole, it is essential that the properties of the material be carefully controlled at stages of mixing, supply to the bore-hole and immediately before concrete is placed. It is usual to limit :

- i) The density of bentonite suspension to 1.05 g/cc.

- ii) The marsh cone viscosity between 30 and 40.
- iii) The pH value between 9.5 and 12.
- iv) The silt content less than 1 per cent.
- v) The liquid limit of bentonite not less than 400 per cent.

These aspects shall act as controlling factors for preventing contamination of bentonite slurry for clay and silt.

The bores shall be washed by bentonite flushing to ensure clean bottom at two stages viz. after completion of boring and prior to concreting after placing of reinforcement cage. Flushing of bentonite shall be done continuously with fresh bentonite slurry till the consistency of inflowing and out-flowing slurry is similar.

Prior to the lowering of the reinforcement cage into the pile shaft, the shaft shall be cleaned of all loose materials. Cover to reinforcing steel shall be maintained by suitable spacers.

Any liner or bore-hole which is improperly located or shows partial collapse that would affect the load carrying capacity of the pile, shall be rejected or repaired as directed by the Engineer at the cost of the Contractor.

The measurement shall be in **Rmt.** of the piles ordered in writing by the Engineer-in-charge, measured from ground level to the bottom of pile foundation.

"The rate of Empty boring for pile shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

Unit rate includes boring through all sorts of strata, providing necessary materials, labour and equipment to complete the work. Steel for reinforcement, liner and concrete for piles will be paid separately.

Item No.4:- Providing and laying controlled cement concrete M 35 for R.C.C. bored piles of 1.20M dia. including ramming , vibrating and finishing excluding cost of T.M.T reinforcement etc. complete.

The work shall consist of furnishing and placing structural concrete and incidental construction in accordance with these specifications and in conformity with the lines, grades and dimensions, as shown -on the drawings or as directed by the Engineer. The relevant clause No. 1100 of MORTH 5th revision on shall be followed for pile work.

1702. MATERIALS

All materials shall conform to Section 1000 of MORT&H Specifications.

1703 GRADES OF CONCRETE

1703.1 The grades of concrete shall be designated by the characteristic strength as given in Table 1700-1, where the characteristic strength is defined as the strength of concrete below which not more than 5 per cent of the test results are expected to fall.

Table 1700-1 : Grades of Concrete

Type of Concrete/Grade Designation			Characteristic Strength in MPa
Nominal Mix Concrete	Standard Concrete	High Performance Concrete	
M15	M15		15
M20	M20		20
	M25		25
	M30	M30	30
	M40	M35	35
	M45	M40	40
	M50	M45	45
		M50	50
		M55	55
		M60	60
		M65	65
		M70	70
		M75	75
		M80	80
		M85	85
		M90	90

1. Nominal Mix Concrete is made on the basis of nominal mix proportioned by weight of its main ingredients – cement, coarse and fine aggregates and water.
2. Standard concrete is made on the basis of design mix proportioned by weight of its ingredients, which in addition to cement, aggregates and water, may contain chemical admixtures to achieve certain target values of various properties in fresh condition, achievement of which is monitored and controlled during production by suitable tests. Generally, concrete of grades up to M50 are included in this type.
3. High Performance Concrete is similar to standard concrete but contains additional one or more mineral admixtures providing binding characteristics and partly acting as inert filler material which increases its strength, reduces its porosity and modifies its other properties in fresh as well as hardened condition. Concrete of grades upto M90 are included in this type.
4. For concrete of grades higher than M90, the design parameters may be obtained from specialized literature and experimental results.

1703.2 The minimum grades of concrete and corresponding minimum cement content and maximum water/cement ratios for different exposure conditions shall be as indicated in Table 1700-2.

1703.3 For concrete subjected to sulphate attack the minimum grades of concrete, minimum cement content and maximum water/cement ratios and types of cement for different concentration of sulphate content shall be as indicated in Table 1700-3.

Table 1700-2: Requirement of Concrete for Different Exposure Condition Using 20mm Aggregate

Exposure Condition	Maximum Water Cement Ratio	Minimum Cement Content, kg/m³	Minimum Grade of Concrete
Moderate	0.45	340	M25
Server	0.45	360	M30
Very Server	0.40	380	M40

Note:

- (i) All three provisions given in the above table for a particular exposure condition, shall be satisfied.
- (ii) The term cement for maximum w/c ratio and minimum cement content shown in Table includes all cementitious materials mentioned in Clause 1715.2. The maximum limit of flyash and ground granulated blast furnace slag in the blended cement shall be as specified in IS:1489(Part 1) and IS:455 respectively.
- (iii) For plain cement concrete, with or without surface reinforcement, the Minimum grade of concrete can be lowered by 5MPa and maximum water/cement ratio exceeded by 0.05.

Cement content shown in the above table shall be increased by 40 kg/m³ for use of 12.50 mm nominal size aggregates and decreased by 30 kg/m³ for use of 40mm nominal size aggregates.

Table 1700-3: Requirement of Concrete Exposed to Sulphate Attack

Class	Concentration of Sulphates as SO ₃			Type of Cement (Note ii)	Minimu m Cement Content kg/m ³	Maximu m Water / Cement Ratio	Minimu m Grade of Concret e
	In Soils		In Ground				
	Total	SO ₃ , in 2:1					

	SO₃, %	Water: Soil Extract, g/l	Water, g/l				
1)	Traces	< 1.0	< 0.3	-OPC, PPC or PSC	280	0.5	M25
2)	2.0 to 0.5	1.0 to 1.9	0.3 to 1.2	-OPC PPC or PSC -SRPC	330	0.5	M25
3)	0.5 TO 1.0	1.9 TO 3.1	1.2 TO 2.5	-SRPC -PPC or PSC	330 350	0.5 0.45	M25 M30
4)	1.0 to 2.0	3.1 to 5.0	2.5 to 5.0	-SRPC	370	0.45	M35
5)	>2.0	>5.0	>5.0	-SRPC With Protectiv e Coatings	400	0.4	M40

Notes: If the requirements of maximum water/cement ratio, minimum grade of concrete and minimum cement content from other durability considerations as given in Table 1700-2 are more stringent than those given in this table, then the former will govern.

OPC: Ordinary Portland Cement, PPC: Portland Pozzolona Cement. PSC:Portland Slag Cement, SRPC: Sulphate Resisting Portland Cement.

The minimum cement content shall be as low as possible but not less than the quantities specified in Table 1700-2 and 1700-3.

The maximum cement content excluding any mineral admixtures (Portland cement component alone) shall not exceed 450 kg/cu.m.

1703.4 Concrete used in any component or structure shall be specified by designation along with prescribed method of design of mix i.e. 'Design Mi' or 'Nominal Mix'. For all items of concrete, only design mix shall be used, except where nominal mix concrete is permitted as per drawing or by the Engineer. Nominal mix may be permitted only for minor bridges and culverts or other incidental construction, where strength

requirements are upto M 20 only. Nominal mix may also be permitted for non-structural concrete or for screed below open foundations.

1703.5 If the contractor so proposes, the Engineer may permit the use of concrete of higher grade than that specified on the drawing, provided the higher grade concrete meets the specifications applicable. The additional cost of such higher grade concrete shall be borne by the Contractor.

1704 PROPORTIONING OF CONCRETE

Prior to the start of construction, the contractor shall design the mix in case of design mix concrete or propose nominal mix in case of nominal mix concrete, and submit to the Engineer for approval, the proportions of materials, including admixtures to be used at the Contractor's option, subject to the approval of the Engineer.

1704.1 Requirements of Consistency

The mix shall have the consistency which will allow proper placement and compaction in the required position. Every attempt shall be made to obtain uniform consistency. Slump test shall be used to measure consistency of the concrete.

The optimum consistency for various types of structures shall be as indicated in Table 1700-4, or as directed by the Engineer. The slump of concrete shall be checked as per IS:516.

Table 1700-4 : Requirements of Consistency

Type		Slump (mm) (at the Time of Placing of Concrete)
1)	a) Structure with exposed inclined surface required low slump concrete to allow proper compaction	25
	b) Plain cement concrete	25
2)	RCC structure with widely spaced reinforcement; e.g. Solid columns, piers, abutments, footings, well staining	40 - 50
3)	RCC structure with fair degree of congestion of reinforcement; e.g. pier and abutment caps, box culverts, Well curb, well cap, walls with thickness greater than 300 mm	50 - 75

4)	RCC and PSC structure with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300 mm	75 - 125
5)	Underwater concreting through tremie e.g. bottom plug, Cast in-situ pilling	150 - 200

Notwithstanding the optimum consistency indicated against SI. No. 1 to 3, the situation should be properly assessed to arrive at the desired workability with the adjustment of admixture in each case, where the concrete is to be transported through transit mixer and placed using concrete pump. Under these circumstances, the optimum consistency during placement for the items of work of SI. No. 1 to 3, can be considered ranging from 75 mm to 150 mm. This is, however, subject to satisfying the other essential criteria of strength, durability etc. and approval of the Engineer.

1704.2 Requirements for Design Mixes

1704.2.1 Target Mean Strength

The target mean strength of specimen shall exceed the specified characteristic compressive strength by at least the current margin.

- i) The current margin for a concrete mix shall be determined by the Contractor and shall be taken as 1.64 times the standard deviation of sample test results taken from at least 40 separate batches of concrete of nominally similar proportions produced at site by the same plant under similar supervision, over a period exceeding 5 days, but not exceeding 6 months.
- ii) Where there is insufficient data to satisfy the above, the current margin for the initial design mix shall be taken as given in Table 1700-5:

Table 1700-5 : Current Margin for Initial Design Mix

Concrete	Current Margin (MPa)	Target Mean Strength (MPa)
M 15	10	25
M 20	10	30
M 25	11	36
M 30	12	42
M 35	12	47
M 40	12	52
M 45	13	58
M 50	13	63
M 55	14	69
M 60	14	74
M 65	15	80

M 70	15	85
M 75	15	90
M 80	15	95
M85	16	101
M90	16	106

The initial current margin given in Table 1700-5 shall be used till sufficient data is available to determine the current margin as per Sub-Clause 1704.2.1(i).

1704.2.2 Trial mixes

The Contractor shall give notice to the Engineer to enable him to be present at the time of carrying out trial mixes and preliminary testing of the cubes. Prior to commencement of trial mix design, all materials forming constituents of proposed design mix should have been tested and approval obtained in writing from the Engineer. Based on that results of material, draft mix design calculation for all grades of concrete to be used in the works, shall be prepared after taking into account the provisions in the contract Technical Specifications, Guidelines of IS:10262, IS:SP:23 and IRC:112 and submitted to the Engineer for approval. Prior to commencement of concreting, trial mix design shall be performed for all grades of concrete and trial mix which has been found successful, shall be submitted by the Contractor and approval obtained. During concreting with the approved trial mix design, if source of any constituents is changed, the mix design shall be revised and tested for satisfying the strength requirements.

The initial trial mixes shall be carried out in a laboratory approved by the Engineer. However, Engineer may permit the initial trial mixes to be prepared at the site laboratory of the Contractor, if a full-fledged concrete laboratory has been established well before the start of construction, to his entire satisfaction. Sampling and testing procedures shall be in accordance with these specifications.

When the site laboratory is utilized for preparing initial mix design, the concreting plant and means of transport employed to make the trial mixes shall be similar to that proposed to be used in the works.

For each trial mix, a set of six cubes shall be made from each of three consecutive batches for purposes of testing. Three cubes from each set of six shall be tested at an age of 28 days and three at an earlier age approved by the Engineer. The cubes shall be made, cured, stored, transported and tested in accordance with these Specifications. The mean strength of the nine cubes at 28 days shall exceed the specified characteristic strength by the current margin minus 3.5 MPa.

1704.2.3 Control of strength of design mixes

(a) Adjustment to Mix Proportions

Adjustments to mix proportions arrived at in the trial mixes shall be made subject to the Engineer's approval, in order to minimize the variability of

strength and to maintain the target mean strength. Such adjustments shall not be taken to imply any change in the current margin.

(b) Change of Current Margin

When required by the Engineer, the Contractor shall recalculate the current margin in accordance with Clause 1704.2.1. The recalculated value shall be adopted as directed by the Engineer, and it shall become the current margin for concrete produced thereafter.

(c) Additional Trial Mixes

In case any changes are observed in the properties of fresh concrete and/or strength of hardened concrete on the basis of early age tests, additional mixes and tests shall be carried out during production, so as to control and bring the quality of concrete within acceptable limits. In case of any change in the source or properties of materials, the design of mix shall be established afresh.

1704.3 Requirements of Nominal Mix Concrete

Requirements for nominal mix concrete unless otherwise specified shall be as given in **Table 1700-6**.

Table 1700-6 : Requirements for Nominal Mix Concrete

Concrete Grade	Total Quantity of Dry Aggregate by Mass per 50 kg of Cement to be taken as the Sum of Individual Masses of Fine and Coarse Aggregates (kg)	Proportion of Fine to Coarse Aggregate (by Mass)	Maximum Quantity of Water for 50 kg of cement (Liters)	
			PCC	RCC
M 15	350	Generally 1:2, subject to upper limit 1:1.5 and lower limit of 1:2.5	25	
M 20	250		25	22

1704.4 Additional Requirements

Concrete shall meet with any other requirements as specified on the drawing or as directed by the Engineer. Additional requirements shall also consist of the following Overall limits of deleterious substances in concrete:

(a) Total acid soluble chloride content in the concrete mix expressed as chloride ions shall not exceed the following values by mass of cement.

- Prestressed Concrete : 0.10 percent
- Reinforced concrete (in sever, very sever

- or extreme exposure condition) : 0.20 percent
 - Reinforced concrete in moderate exposure Condition : 0.30 percent
- (b) The total water soluble sulphate content of the concrete mix expressed as SO₃, shall not exceed 4 percent by mass of cement in the mix.

For concrete made with Portland pozzolona cement, Portland blast furnace slag cement or mineral admixtures. the setting time and rate of gain of strength are different from those for concrete made with OPC alone. Such modified properties shall be taken into account while deciding the de-shuttering time, curing period, early age loading and time of prestressing. Additional cube samples may be required to be taken for verifying the concrete properties.

1704.5 Suitability of Proposed Mix Proportions

The Contractor shall submit the following information for the Engineer's approval:

- a) Nature and source of each material
- b) Quantities of each material per cubic meter of fully compacted concrete
- c) Either of the following :
 - (i) appropriate existing data as evidence of satisfactory previous performance for the target mean strength, current margin, consistency and water/cement ratio and any other additional requirements) as specified
 - (ii) Full details of tests on trial mixes.
- d) Statement giving the proposed mix proportions for nominal mix concrete

Any change in the source of material or in the mix proportions shall be subject to the Engineer's prior approval.

1704.6 Checking of Mix Proportions and Water/Cement Ratio

In proportioning concrete, the quantity of both cement and aggregate shall be determined by weight. Where the weight of cement per bag as given by the manufacturer is accepted, a reasonable number of bags shall be weighed separately to check the net weight. Where cement is weighed from bulk stock at site and not by bag, it shall be weighed separately from the aggregates. Water shall either be measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be periodically checked.

The specified water/cement ratio shall always be kept constant and at its correct value. To this end, moisture content in both fine and coarse aggregates shall be determined as frequently as possible, the frequency for a given job being determined by the Engineer according to the weather conditions. The amount of water to be added shall then be adjusted to compensate for variations in moisture content. For the determination of moisture content in the aggregates IS:2386 (Part III) shall be referred. Suitable adjustments shall also be made in the weight of aggregates to allow for their variation in their moisture content.

1704.7 Grading of \aggregates for Pumped Concrete

Materials for pumped concrete shall be batched consistently and uniformly. Maximum size of aggregate shall not exceed one-third of the internal diameter of the pipe.

The grading of aggregates shall be continuous and shall have sufficient ultra fine materials (material finer than 0.25 mm). Proportion of fine aggregates passing through 0.25 mm shall be between 15 and 30 percent and that passing through 0.125 mm sieve shall not be less 5 percent of the total volume of aggregate. Admixtures to increase workability can be added. When pumping long distance and in hot weather, set-retarding admixtures can be used. Fluid mixes can be pumped satisfactory after adding plasticisers. Suitability of concrete shall be verified by trial mixes and by performing pumping test.

1705 ADMIXTURES

1705.1 Chemical Admixtures

Chemical admixtures such as superplasticisers, or air entraining, water reducing, accelerating and retarding agents for concrete, may be used with the approval of the Engineer.

As the selection of an appropriate concrete admixture is an integral part of the mix design, the manufacturers shall recommend the use of any one of their products only after obtaining complete information of all the actual constituents of concrete as well as methodologies of manufacture, transportation and compaction of concrete proposed to be used in the work. Admixtures/additives conforming to IS:9103 may be used subject to approval of the Engineer. However, admixtures/additives generating hydrogen or nitrogen and containing chlorides, nitrates, sulphides, sulphates or any other material likely to adversely affect the steel or concrete, shall not be permitted.

The general requirements for admixtures are given in Clause 1007 of these Specifications.

Compatibility of the admixtures with the cement and any other pozzolona or hydraulic addition shall be ensured by for avoiding the following problems

- i) Requirement of large dosage of superplasticiser for achieving desired workability.
- ii) Excessive retardation of setting.
- iii) Excessive entrainment of large air bubbles.
- iv) Unusually rapid stiffening of concrete.
- v) Rapid loss of slump
- vi) Excessive segregation and bleeding.

1705.2 Mineral Admixtures

For use of mineral admixtures, refer Clauses 1714.1 and 1715.2.

1706 SIZE OF COARSE AGGREGATE

The size (maximum nominal) of coarse aggregates for concrete to be used in various components shall be given as Table 1700-7.

TABLE 1700-7 : Maximum Nominal Size of Coarse Aggregates

Components	Maximum Nominal Size of Coarse Aggregate (mm)
i) RCC well curb	20
ii) RCC/PCC well staining	40
iii) Well cap or Pile Cap Solid type piers and abutments	40
iv) RCC work in girders, slabs, wearing coat, kerb, approach slab, hollow piers and abutments, pier/abutment caps, piles	20
v) PSC work	20
vi) Any other item	As specified by the Engineer

Maximum nominal size of aggregates shall also be restricted to the smaller of the following values :

- a) 10 mm less than the minimum lateral clear distance between main reinforcements
- b) 10 mm less than the minimum clear cover to the reinforcements
- c) One quarter of minimum thickness of member

The proportions of the various individual size of aggregates shall be so adjusted that the grading produces densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

1707. EQUIPMENT

Unless specified otherwise, equipment for production, transportation and compaction of concrete shall be as under:

- a) Production of Concrete:
 - i) For overall bridge length of less than 200 m – batch type concrete mixer, diesel or electric operated, with a minimum size of 200 liters automatic water measuring system and integral weighed (hydraulic/pneumatic type)
 - ii) For overall bridge length of 200 m or more – concrete batching and mixing plant fully automatic, with minimum capacity of 15 cum per hour.

All measuring devices of the equipment shall be maintained in a clean and serviceable condition. Its accuracy shall be checked over the range in use, when set up at each site and thereafter periodically as directed by the Engineer.

The accuracy of the measuring devices shall fall within the following limits:

Measurement of Cement	: ± 3 percent of the quantity of cement in each batch
Measurement of Water	: ± 3 percent of the quantity of water in each batch
Measurement of Aggregate	: ± 3 percent of the quantity of aggregate in each batch
Measurement of Admixture	: ± 3 percent of the quantity of admixture in each batch

- b) Transportation of Concrete :

- i) Concrete dumpers minimum 2 tonnes capacity
- ii) Powered hoists minimum 0.5 tonnes capacity Chutes
- iii) Buckets handled by cranes
- iv) Transit truck mixer
- v) Concrete pump
- vi) Concrete distributor booms
- vii) Belt conveyor
- viii) Cranes with skips
- ix) Tremies
- c) For Compaction of Concrete :
 - i) Internal vibrators size 25mm to 70mm
 - ii) Form vibrators minimum 500 watts
 - iii) Screed vibrators full width of carriageway (upto two lanes)

1708 BATCHING, MIXING, TRANSPORTING, PLACING AND COMPACTION

1708.1 General

Prior to start of concreting, the Contractor shall submit for approval of the Engineer, his programme along with list of equipment proposed to be used by him for batching, mixing, transporting and placing concrete.

1708.2 Batching of Concrete

In batching concrete:

- The quantity of cement, aggregate and mineral admixtures, if used, shall be determined by mass.
- Chemical admixtures, if solid, shall be determined by mass.
- Liquid admixtures may be measured in volume or mass, and
- Water shall be weighed or measured by volume in a calibrated tank.

The concrete shall be sourced from on-site or off-site batching and mixing plants, or from approved Ready Mixed Concrete plants, preferably having quality certification.

Except where supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading of aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, the different sizes being stocked in separate stock piles. The materials should be stock piled several hours, preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible to ensure that the specified grading is maintained.

The water/cement ratio shall always be maintained constant at its correct value. To this end, determination of moisture content in both fine and coarse aggregates shall be made as frequently as possible, depending on weather conditions. The amount of added water shall be adjusted to compensate for any observed variations in the moisture content. To allow for the variation in mass of aggregate due to variation in moisture content, suitable adjustment in the mass of aggregate, shall also be made. Accurate control shall be kept on the quantity of mixing water, which when specified, shall not be changed without approval.

1708.3 Mixing Concrete

1708.3.1 Mixing at Site

All concrete shall be machine mixed. In order to ensure uniformity and good quality of concrete the ingredients shall be mixed in a power driven batch mixer with hopper and suitable weigh batching arrangement or in a central mix plant. Hand mixing shall not be permitted. The mixer or the plant shall be at an approved location considering the properties of the mixes and the transportation arrangements available with the contractor. The mixer or the plant shall be approved by the Engineer.

Mixing shall be continued till materials are uniformly distributed and a uniform colour of the entire mass is obtained, and each individual particle of the coarse aggregate shows complete coating of mortar containing its proportionate amount of cement. In no case shall mixing be done for less than 2 minutes. It shall be ensured that the mixers are not loaded above their rated capacities and are operated at a speed recommended by the manufacturer. When mineral admixtures are added at the mixing stage, their thorough and uniform blending with cement shall be ensured, if necessary by longer mixing time. The addition of water after the completion of the initial mixing operation, shall not be permitted.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch and also before changing from one type of cement to another.

1708.3.2 Ready Mix Concrete

Use of ready mix concrete proportioned and mixed off the project site and delivered to site in a freshly mixed and unhardened state conforming to IS:4926, shall be allowed with the approval of the Engineer.

1708.4 Transporting Concrete

Mixed concrete shall be transported from the place of mixing to the place of final deposit as rapidly as possible by methods which will prevent the segregation or loss of the ingredients. The method of transporting or placing of concrete shall be approved by the Engineer. Concrete shall be transported and placed as near as practicable to its final position so that no contamination, segregation or loss of its constituents materials take place.

Concrete may be transported by transit mixers or properly designed buckets or by pumping. Transit mixers or other hauling equipment when used should be equipped with the means of discharge of concrete without segregation. During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to be reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute be so adjusted that the concrete flows without excessive quantity of water and without any segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before and after each working period and the water used for this purpose shall be discharged outside the formwork.

In case concrete is to be transported by pumping, the fresh concrete should have adequate fluidity and cohesiveness to be pumpable. Proper concrete mix proportioning and initial trials should ensure this. The conduit shall be primed by pumping a batch of mortar through the line to lubricate it. Once the pumping is started, it shall not be interrupted, as concrete standing idle in the line is liable to cause plug. The operator shall ensure that some concrete is always there in the pump's receiving hopper during operation. The lines shall always be maintained clean and free of dents.

Pipelines from the pump to the placing area shall be laid with minimum bends. For large quantity placements, standby pumps shall be available. Suitable air release valves, shutoff valves etc. shall be provided as per site requirements. The pumping of priming mix i.e. rich mix of creamy consistency, to lubricate the concrete pump and pipelines, shall precede the pumping of concrete. Continuous pumping shall be done to the extent possible. After concreting, the pipelines and accessories shall be cleaned immediately. The pipes for pumping shall not be made of material which has adverse effect on concrete. Aluminum alloy pipelines shall not be used.

1708.5 Placing of Concrete

All formwork and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete.

No concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained. If concreting is not started within 24 hours of the approval being given, it shall have to be obtained again from the Engineer. Concreting then shall proceed continuously over the area between the construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a proper construction joint is formed.

The concrete shall be deposited as nearly as practicable in its original position to avoid re-handling. Methods of placing should be such as to preclude segregation. Care should be taken to avoid displacement of reinforcement or movement of formwork. To achieve this, concrete should be lowered vertically in the form and horizontal movement of concrete inside the forms should, as far as practicable, be minimized.

The concrete shall be placed and compacted before its initial setting so that it is amenable to compaction by vibration. The workability of concrete at the time of placement shall be adequate for the compaction equipment to be used. If there is considerable time gap between mixing and placing of concrete, as in the case of ready mixed concrete plants or off-site batching and mixing plants, concrete mix shall be designed to have appropriately higher workability at the time of discharge from the mixer, in order to compensate the loss of workability during transit. This is generally achieved by suitable chemical admixtures. Keeping these considerations in view, the general requirement for ready mixed concrete plants or off-site batching and mixing plants, is that concrete shall be discharged from the truck mixer within two hours of the time of loading. A longer period may be permitted if suitable retarding admixtures are used.

In the wall forms, drop chutes attached to hoppers at the top should preferably be used to lower concrete to the bottom of the form. As a general guidance, the permissible free fall of concrete may not exceed 1.5 meters and under no circumstances shall it be more than 2 meters. When free fall of larger height is involved, self compacting concrete having adequate fluidity, cohesiveness and viscosity and which uniformly and completely fills every corner of the formwork by its own weight without segregation, shall be used.

Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used and not exceeding 300 mm in all other cases.

Concrete when deposited shall have a temperature of not less than 5° C and preferably not more than 30° C and in no case more than 40°C. It shall be compacted in its final position within 30 minutes of its discharge from the mixer, unless carried in properly designed agitators, operating continuously, when this time shall be within 1 hour of the addition of cement to the mix and within 30 minutes of its discharge from the agitator. It

may be necessary to add retarding admixtures to concrete if trials show that the periods indicated above are unacceptable. In all such matters, the Engineer's decision shall be final.

1708.6 Compaction of Concrete

Concrete shall be thoroughly compacted by vibration or other means during placing and worked around the reinforcement, tendons or duct formers, embedded fixtures and into corners of the formwork to produce a dense homogeneous void-free mass having the required surface finish. When vibrators are used, vibration shall be done continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation. Over vibration shall be avoided to minimize the risk of forming a weak surface layer. When external vibrators are used, the design of formwork and disposition of vibrator shall be such as to ensure efficient compaction and to avoid surface blemishes. Vibrations shall not be applied through reinforcement and where vibrators of immersion type are used, contact with reinforcement and all inserts like ducts etc. shall be avoided.

When internal vibrators are used, they shall be inserted vertically to the depth of the layer being placed and ordinarily shall penetrate the layer below for a few centimeters. The vibrator should be kept in place until air bubbles cease escaping from the surface and then withdrawn slowly to ensure that no hole is left in the concrete, care being taken to see that it remains in continued operation while being withdrawn. The internal vibrators shall be inserted in an orderly manner and the distance between insertions should be about one and a half times the radius of the area visibly affected by vibration. Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns.

Mechanical vibrators used shall comply with IS:2502, IS:2506, IS:2514 and IS:4656.

1709. CONSTRUCTION JOINTS

Construction joints shall be avoided as far as possible. In no case shall the locations of such joints shall be changed or increased from those shown on the drawings except with express approval of the Engineer.

Joints should be positioned where they are readily accessible for preparation and concreting. Construction joints should be positioned to minimize the effects of the discontinuity of the durability, structural integrity and appearance of the structure. As far as possible, joints should be provided in non-aggressive zones, but if joints in aggressive zones cannot be avoided, they should be sealed. Joints should be located away from the regions of maximum stress caused by loading; particularly where shear and bond stresses are high.

In beams and slabs joints should not be near the supports. Construction joints between slabs and ribs in composite beams, shall be avoided. For box girders, there shall be no construction joint between the soffit and webs.

Joints should be either vertical or horizontal. For a vertical construction joint, the lifts of concrete shall finish level or at right angles to the axis of the member. Concreting shall be continued right up to the joint.

Before resuming work at a construction joint when concrete has not yet fully hardened, All laitance shall be removed thoroughly. The surface shall be roughened, taking care to avoid dislodgement of coarse aggregates. Concrete shall be brushed with a stiff brush soon after casting, while the concrete has only slightly stiffened. If the concrete has partially hardened, it may be treated by wire brushing or with a high pressure water jet, followed by drying with an air jet, immediately before the new concrete is placed. Fully hardened concrete shall be treated with mechanical hand tools or grit blasting, taking care not to split or crack aggregate particles. The Practice of first placing a layer of mortar or grout when concreting joints, shall be avoided. The old surface shall be soaked with water, without leaving puddles, immediately before starting concreting. The new concrete shall be thoroughly compacted against it.

Where there is likely to be a delay before placing the next concrete lift, protruding reinforcement shall be protected. In all cases, where construction joints are made, the joint surface shall not be contaminated with release agents, dust, or sprayed curing membrane and reinforcement shall be firmly fixed in position at the correct cover.

The sequence of concreting, striking of forms and positioning of construction joints for every individual structure, shall be decided well in advance of the commencement of work.

1710 CONCRETING UNDER WATER

When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of mix to be used, shall be got approved from the Engineer before any work is started.

Concrete shall not be placed in water having a temperature below 5°C. The temperature of the concrete, when deposited, shall not be less than 16°C, nor more than 30°C.

Coffer dams or forms shall be sufficiently tight to ensure still water conditions, if practicable, and in any case to reduce the flow of water to less than 3 m per minute through the space into which concrete is to be deposited. Coffer dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping shall not be done while concrete is being placed, or until 24 hours thereafter. To minimise the formation of laitance, care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

All under water concreting shall be carried out by tremie method only. The number and spacing of the tremies should be worked out to ensure proper concreting. However, it is necessary to have a minimum number of 2 tremies for any concreting operation, so that even if one of the tremies goes out of commission during concreting, the other one can be used to complete the work. The tremie concreting when started, should continue without interruption for the full height of the member being concreted. The capacity of the concrete production and placement equipment should be sufficient to enable the underwater concreting to be completed uninterrupted within the stipulated time.

The top section of the tremie shall have a hopper large enough to hold one full batch of the mix or the entire contents of the transporting bucket, as the case may be. The tremie pipe shall not be less than 200 mm in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably, flanged steel pipe of adequate strength shall be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with a wadding of gunny sacking or other approved material before delivering the concrete to the tremie pipe through the hopper, so that when the concrete is forced down from the hopper to the pipe, it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end, thus establishing a continuous stream of concrete. It will be necessary to raise the tremie slowly in order to allow a uniform flow of concrete. At all times after placing of concrete is started and until all the required quantity has been placed, the lower end of the tremie pipe shall be kept below the surface of the plastic concrete and shall not be taken out of concrete. This will cause the concrete to build up from below instead of flowing out over the surface and thus avoid formation of layers of laitance. It is advisable to use retarders or suitable superplasticizers to retard the setting time of concrete, which shall be established before the commencement of work.

1711 CONCRETING IN EXTREME WEATHER

1711.1 Concreting in Cold Weather

Where concrete is to be deposited at or near freezing temperature, precautions shall be taken to ensure that at the time of placing, it has a temperature of not less than 5°C and that the temperature shall be maintained above 4°C until the concrete has hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated artificially other than by the heat transmitted to it from other ingredients of the concrete. Stock piled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or on sheet metal over fire. In general, the temperature of aggregates or water shall not exceed 65°C. Salt or other chemicals shall not be used for the prevention of freezing. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. Concrete exposed to freezing weather shall have entrained air and the water content of the mix shall not exceed

30 liters per 50 kg of cement. To counter slower setting of concrete, accelerators can be used with the approval of the Engineer. However, accelerators containing chloride shall not be used.

1711.2 Concreting in hot Weather

When depositing concrete in hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 30°C while placing. This shall be achieved by using chilled mixing water, using crushed ice as a part of mixing water, shading stock piles of aggregates from direct rays of the sun, sprinkling the stock piles of coarse aggregate with water to keep them moist, limiting temperature of cement below 30°C at the time of use, starting curing before concrete dries out and restricting time of concreting as far as possible to early mornings and late evenings. When ice is used to cool mixing water, it will be considered as part of the water in design mix. Under no circumstances shall the mixing operation be considered complete until all ice in the mixing drum has melted. The Contractor will be required to state his methodology for the Engineer's approval when temperatures of concrete are likely to exceed 30°C during the work.

1712 PROTECTION AND CURING

1712.1 General

Concreting operations shall not commence until adequate arrangements for concrete curing have been made by the Contractor. Curing and protection of concrete shall start immediately after compaction of the concrete.

The concrete shall be protected from:

- a) Premature drying out particularly by solar radiation and wind
- b) High internal thermal gradients
- c) Leaching out by rain and flowing water
- d) Rapid cooling during the first few days after placing
- e) Low temperature or frost
- f) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.
- g) Vibration caused by traffic including construction traffic.

Concrete shall be protected, without allowing ingress of external water, by means of wet (not dripping) gunny bags, hessian etc. Once the concrete has attained some degree of hardening (approximate 12 hrs after mixing), moist curing shall commence and be continued through the requisite period. Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

1712.2 Water Curing

Water for curing shall be as specified in Section 1000 of these specifications.

Sea water shall not be used for curing. Sea water shall not come into contact with concrete members before they have attained adequate strength.

The concrete should be kept constantly wet by ponding or covering or use of sprinklers/perforated pipes for a minimum period of 14 days after concreting, except in the case of concrete with rapid hardening cement, where it can be reduced to 5 days. Water should be applied on surfaces after the final set. Curing through watering shall not be done on green concrete. On formed surfaces, curing shall start immediately after the forms are stripped. The concrete shall be kept constantly wet with a layer of sacking, canvas, hessian or similar absorbent material.

1712.3 Steam Curing

Where steam curing is adopted, it shall be ensured that it is done in suitable enclosure to contain the live steam in order to minimize moisture and heat losses. The initial application of the steam shall be after about four hours of placement of concrete to allow the initial set of the concrete to take place.

Where retarders are used, the waiting period before application of the steam shall be increased to about six hours.

The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. The application of steam shall not be directly on the concrete. Steam curing is applied in enclosures or tunnels through which concrete members are transported on a conveying system. Alternatively, portable enclosures or plastic covers are placed over precast members and steam is supplied to the enclosures. The rate of increase or decrease of temperature should not be more than 10°C to 20°C per hour and the maximum temperature shall be about 70°C. The maximum temperature shall be maintained until the concrete has attained the desired strength required at the end of steam curing period and shall be decided by prior trials. When steam curing is discontinued, the air temperature shall not drop at a rate exceeding 10°C per hour, until a temperature of about 10°C above the ambient temperature outside has been reached. Steam curing of concrete shall be followed by water curing for at least 7 days. The concrete shall not be exposed to temperatures below freezing for at least six days after curing.

1712.4 Curing Compound

Membrane forming curing compounds consisting of waxes, resins, chlorinated rubbers etc. may be permitted by the Engineer in special circumstances. Curing compounds shall not be used on any surface which requires further finishing to be applied. All construction

joints shall be moist cured and no curing compound shall be permitted in locations where concrete surfaces are required to be bonded together.

Liquid membrane forming compounds shall conform to ASTM C 309 and the curing efficiency shall be as per ASTM C 156.

Curing compounds shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of concrete finish. If the surface is dry, the concrete shall be saturated with water and curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking. The membrane formed shall be stripped off after 14 days, when curing is complete. Impermeable membranes, such as sheet materials for curing concrete conforming to ASTM C 171 or polyethylene sheeting covering closely the concrete surface, may also be used to provide effective barrier against evaporation.

1713 FINISHING

Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes filled with cement mortar. All fins caused by form joints, all cavities produced by the removal of form ties and all other holes and depressions, honeycomb spots, broken edges or corners, and other defects, shall be thoroughly cleaned, saturated with water and carefully pointed and rendered true with mortar. The mortar shall be of cement and fine aggregate mixed in the proportions used in the grade of concrete that is being finished and of as dry a consistency as possible. Considerable pressure shall be applied in filling and pointing to ensure thorough filling in all voids. Surfaces which have been pointed shall be kept moist for a period of twenty four hours. Special pre-packaged proprietary mortars shall be used where appropriate or where specified in the drawing.

All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

Immediately on removal of forms, the concrete work shall be examined by the Engineer before any defects are made good. The work that has sagged or contains honeycombing to an extent detrimental to structural safety or architectural appearance of the member, shall be rejected. Surface defects of a minor nature may be accepted. On acceptance of such work, the same shall be rectified as directed by the Engineer.

1714 CONCRETE WITH BLENDED CEMENTS OR MINERAL ADMIXTURES

1714.1 Production of Concrete

In order to improve the durability of the concrete, use of blended cement or blending of mineral admixtures, is permitted. The maximum limit of flyash and ground granulated blast furnace slag in concrete, shall be as specified in Clause 1715.2. Blending at site shall be permitted only through a specific facility with complete automated process control to achieve the specified design quality or through RMC plants with similar facility.

1714.2 Modified Properties

For concrete made with Portland Pozzolona Cement, Portland Blast furnace slag cement or mineral admixtures, the setting time and rate of gain of strength are different from those of concrete made with OPC alone. Cognizance of such modified properties shall be taken in deciding de-shuttering time, initial time of prestressing, curing period and for early age loading.

1714.3 Compatibility of Chemical Admixtures

Compatibility of chemical admixtures and superplasticizers with Portland Pozzolona cement, Portland blast furnace slag cement and mineral admixtures shall be ensured by trials outlined in Clause 1705.

1714.4 Additional Tests

In addition to the strength tests prescribed in other Sections of these Specifications, the following additional tests are required to be carried out from considerations of durability.

i) **Rapid Chloride Ion Permissibility Test**

Rapid Chloride Ion permeability test on as per ASTM C 1202 at 56 days for extreme, very severe and severe conditions of exposure. The permissible value of Chloride-Ion permeability for extreme condition 800 Coulombs very severe condition 1200 coulombs and severe exposure condition 1500 coulombs.

ii) **Water Permeability Test**

Water permeability test as per DIN: 1048 Part 5-1991 shall be carried out as described in Clause 1717.2.5.5.

1715 HIGH PERFORMANCE CONCRETE

1715.1 General

High Performance Concrete shall be used where special performance requirements of high strength, high early strength, high workability, low permeability and high durability for severe service environments, are required. Production and use of such concrete in the field shall be carried out with high degree of uniformity between batches and very stringent quality control.

1715.2 Materials

Cement, mineral admixtures, chemical admixtures, aggregates and water shall conform to Section 1000 of these Specifications and this Section.

Flyash when used, shall neither be less than 20 percent nor shall be greater than 35 percent of the total by mass of ordinary Portland cement and flyash and shall conform to grade-1 of IS:3812.

Ground granulated blast furnace (GGBS) slag when used, shall neither be less than 50 percent nor greater than 70 percent of the total mass of ordinary Portland cement and GGBS and shall conform to IS:12089, Silica fume conforming to IS:15388 shall be used.

The cement content of concrete inclusive of any mineral admixtures shall not be less than 380 kg/m³. The cement content excluding any mineral admixtures (Portland cement content alone) shall not exceed 450 kg/m³. The water/cement (cement plus all cementitious materials) ratio should generally not exceed 0.33 but in no case shall be more than 0.40.

1715.3 Compatibility of Admixtures

Compatibility of the superplasticizer and admixtures with the cement and any other Pozzolanic or hydraulic dilutes shall be ensured by trials as outlined under Clause 1705.

1715.4 Characteristic Strength and Target Mean Strength

Characteristic strength and the initial target mean strength of concrete, shall be as given in Table 1700-8. The target mean strength shall be calculated as per Clause 1704.2 after obtaining data on standard deviation from sufficient samples.

Table 1700-8 : Characteristic Compressive Strength and Target Mean Strength

Grade Designation	Specified Characteristic Compressive Strength at 28 days (MPa)	Target Mean Strength (MPa)
M 40	40	52
M 45	45	58
M 50	50	63
M 55	55	69

M 60	60	74
M 65	65	80
M 70	70	85
M 75	75	90
M 80	80	95
M 85	85	101
M 90	90	106

1715.5 Workability and Other Requirements

Workability, concrete mix design, field trial mixes, chloride and sulphate contents shall be as laid down in other Sections of these Specifications.

1715.6 Mixing of Concrete

The concreting plant and means of transportation employed to make trial mixes and to transport them to representative distances shall be similar to the corresponding plant and transport to be used in the works. The optimum sequence of mixing of ingredients shall be established by trials. Mixing time may be longer than in normal grade concrete mixes.

The temperature of concrete at the time of placement shall not exceed 25°C. The temperature of concrete at the mixing stage should be lower, to allow for rise in temperature during transport. When considerable distance of transport is involved, particular attention should be paid to ensure retention of slump as targeted for placement.

1715.7 Prototype Testing

Mock-up trials or prototype testing may be carried out to ensure that the concrete can be satisfactorily placed and compacted, taking into account the location of placement and provision of reinforcement, and required adjustments made in concrete mix design and/or detailing of reinforcement.

1715.8 Curing of Concrete

High performance concrete containing silica fume is more cohesive than normal mixes hence, there is a little or no bleeding and no bleed water to rise to the surface to offset water loss due to evaporation. Plastic shrinkage cracking is possible, if curing is not proper. Initial curing should commence soon after initial setting of concrete. Concrete should be covered with moist covers, opaque colour plastic sheets or suitable curing compound. Final moist curing should commence after final setting of concrete and continue for at least 14 days.

1715.9 Additional Tests for Concrete

Apart from the strength tests prescribed in other Sections of these Specifications, the additional tests as specified under Clause 1714.3, shall also be carried out.

1716 TOLERANCES

Tolerances for dimensions/shape of various components shall be as indicated in these Specifications or shown on the drawings or as directed by the Engineer.

1717 TESTS AND STANDARDS OF ACCEPTANCE

1717.1 Concrete shall conform to the surface finish and tolerance as prescribed in these Specifications for respective components.

1717.2 Random sampling and lot by lot acceptance inspection, shall be made for the 28 days cube strength of concrete.

1717.3 Concrete under acceptance, shall be notionally divided into lots for the purpose of sampling before commencement of work. The basis of delimitation of lots shall be as follows:

- i) No individual lot shall be more than 30 cu.m in volume
- ii) Different grades of mixes of concrete shall be divided into separate lots.
- iii) Concrete of a lot shall be used in the same identifiable component of the bridge.

1717.4 Sampling and Testing

Concrete for preparing 3 test cubes shall be taken from a batch of concrete at point of delivery for construction, according to procedure laid down in IS:1199.

A random sampling procedure shall be adopted which ensures that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes.

150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS:516. The 28 day test strength result for each cube shall form an item of the sample. Tests at other age shall also be performed, if specified.

Where automated batching plant/Ready Mixed Concrete Plant is located away from the place of use and the time gap between production and placement is more than the initial setting time or where any ingredients are added subsequent to mixing, separate sets of samples shall be collected and tested at batching plant and at location of placement. The results shall be compared and used to make suitable adjustment at batching plants so that properties of concrete at placement are as per the requirements.

1717.5 Test Specimen and Sample Strength

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose.

The test strength of the sample shall be the average of the strength of 3 cubes. The individual variation should not be more than ± 15 percent of the average. If variation is more, the test results of the sample are invalid.

1717.6 Frequency

The minimum frequency of sampling of concrete of each grade shall be in accordance with Table 1700-9.

Table 1700-9 : Minimum Frequency of Sampling

Quantity of Concrete in Work, m³	No. of Samples
1 — 5	1
6 — 15	2
16 — 30	3
31 — 50	4
51 and above	4 plus one additional sample for each additional 50 m ³ or part thereof

At least one sample shall be taken from each shift of work.

1717.7 Acceptance criteria

1717.7.1 Compressive Strength

1) Cubes

The concrete shall be taken as having the specified compressive strength when both the following conditions are met:

- The mean strength determined from any group of four consecutive non-overlapping samples exceeds the specified characteristic compressive strength by 3 MPa.
- Strength of any sample is not less than the specified characteristic compressive strength minus 3 MPa.

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches.

2) Cores

When the concrete does not satisfy both the conditions given in (1) above, representative cores shall be extracted from the hardened concrete for compression test in accordance with the method described in IS:1199 and tested to establish whether the concrete satisfies the requirement of compressive strength.

Evaluation of compressive strength by taking cores may also be done in case of doubt regarding the grade of concrete used either due to poor workmanship or based on results of cube strength tests.

The locations from which core samples are to be taken and their number shall be decided so as to be representative of the whole of the concrete under consideration. However, in no case shall fewer than three cores be tested. Cores shall be prepared and tested as described in IS:516. Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has strength less than 75 percent of the specified strength.

1717.7.2 Chloride and Sulphate Content

The total chloride and sulphuric anhydride (SO_3) content of all the constituents of concrete as a percentage of mass of cement in the mix, shall not exceed the values given in this Section.

1717.7.3 Density of Fresh Concrete

Where minimum density of fresh concrete is specified, the mean of any four consecutive non-overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 percent of the specified value.

1717.7.4 Density of Hardened Concrete

Where minimum density of hardened concrete is specified, the mean of any four consecutive non-overlapping samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 percent of the specified value.

1717.7.5 Permeability Test

Water permeability test as per DIN:1048 Part 5-1991 shall be carried out as described below :

- i) A cylindrical test specimen 150 mm dia and 160 mm high shall be prepared.
- ii) After 28 days of curing, the test will be conducted between 28 and 35 days. The test specimen shall be fitted in a machine such that specimen can be subjected to a water pressure of up to 7 bars. Atypical machine is shown in Appendix-1700/1.
- iii) The concrete specimen shall be subjected to a water pressure of 0.5 N/mm² from the top for a period of 3 days. The pressure shall be maintained constant throughout the test period. If the water penetrates through to the underside of the specimen, the test may be terminated and the specimen rejected as failed.
- iv) After 3 days, the pressure shall be released and the sample shall be taken out. The specimen shall be split in the middle by compression applied on two round bars on opposite sides above and below.
- v) When the split faces show signs of drying (after 5 to 10 minutes), the maximum depth of penetration in the direction of height shall be measured with the scale and extent of water penetration established.
- vi) The mean of maximum depth of penetration obtained from three specimens thus tested, shall be taken as the test result and it shall not exceed 25 mm.

1717.7.6 If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. The Engineer may accept the concrete as sub-standard work. Any additional work required by the Engineer for such acceptance, shall be carried out by the Contractor at his cost. In case the concrete is not found to be acceptable even after investigation, the Contractor shall remove the rejected concrete forthwith.

1717.7.7 When durability of concrete is desired the rapid chloride ion permeability test as stated under Clause 1714.3.1 shall also be performed in addition to above tests.

1500 FORM WORK

1501 DESCRIPTION

Formwork shall include all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish, as shown on the drawing or as

directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support.

1502 MATERIALS

All materials shall comply with the requirements of IRC:87. Materials and components used for formwork shall be examined for damage or excessive deterioration before use/re-use and shall be used only if found suitable after necessary repairs. In case of timber formwork, the inspection shall not only cover physical damages but also signs of attacks by decay, rot or insect attack or the development of splits.

Forms shall be constructed with metal or timber. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolts should be countersunk. The use of approved internal steel ties or steel or plastic spacers shall be permitted. Structural steel tubes used as support for forms shall have a minimum wall thickness of 4 mm. Other materials conforming to the requirements of IRC:87 may also be used if approved by the Engineer.

1503 DESIGN OF FORMWORK

1503.1 The design, erection and removal of formwork shall conform to IRC:87 "Guidelines for Formwork, Falsework and Temporary Structures" and these specifications. The forms shall be such as to ensure that they can be conveniently removed without disturbing the concrete. The design shall facilitate proper and safe access to all parts of formwork for inspection.

1503.2 The Contractor shall furnish the design and drawing of complete formwork (i.e. the forms as well as their supports) for approval of the Engineer before any erection is taken up. If proprietary system of formwork is used, the Contractor shall furnish detailed information as per Appendix 1500/I, to the Engineer for approval.

Notwithstanding any approval or review of drawing and design by the Engineer, the Contractor shall be entirely responsible for the adequacy and safety of formwork.

1503.3 In the case of prestressed concrete superstructure, careful consideration shall be given to redistribution of loads on props due to prestressing.

1504 WORKMANSHIP

1504.1 The formwork shall be robust and strong and the joints shall be leak-proof. Ballies shall not be used as staging. Staging must have cross bracings and diagonal bracings in both directions. Staging shall be provided with an appropriately designed base plate resting on firm strata.

1504.2 The number of joints in the formwork shall be kept to a minimum by using large sized panels. The design shall provide for proper "soldiers" to facilitate alignment. All joints shall be leak proof and must be properly sealed. Use of PVC joint sealing tapes, foam rubber or PVC T-section, is essential to prevent leakage of grout.

1504.3 As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable, minimum number of nails shall be used and these shall be of the double-headed type. Alternatively, if the nails are of the normal type, they shall be left partially projecting without being driven to their full length, so that they can be withdrawn easily.

1504.4 Use of ties shall be restricted, as far as practicable. Wherever ties are used they shall be used with HDPE sheathing so that they can easily be removed. No parts prone to corrosion shall be left projecting or near the surface. The sheathing shall be grouted with cement mortar of the same strength as that of the structure.

1504.5 Unless otherwise specified, or directed, chamfers or fillets of size 25 mm x 25 mm shall be provided at all angles of the formwork to avoid sharp corners. The chamfers, beveled edges and mouldings shall be made in the formwork itself. Opening for fixtures and other fittings shall be provided in the shuttering as directed by the Engineer.

1504.6 Shuttering for walls, sloping members and thin sections of considerable height shall be provided with temporary openings to permit inspection and cleaning out before placing of concrete.

1504.7 The formwork shall be constructed with pre-camber to the soffit to allow for deflection of the formwork. This shall be in addition to the pre-camber for the permanent structure as shown on the drawings.

1504.8 Where centering trusses or launching trusses are adopted for casting of superstructure, the joints of the centering trusses, whether welded, riveted or bolted shall be thoroughly checked periodically. Also, various members of the centering trusses should be periodically examined for proper alignment and unintended deformation before proceeding with the concreting. They shall also be periodically checked for any deterioration in quality due to steel corrosion. Launching truss, casting truss of span more than 40 m and travelling forms, shall be load tested before they are put to use.

1504.9 The formwork shall be so made as to produce a finished concrete true to shape, line and levels and dimensions as shown on the drawings, subject to the tolerances specified in respective Sections of these specifications, or as directed by the Engineer.

1504.10 Where metal forms are used, all bolts and rivets shall be countersunk and well ground to provide a smooth, plane surface. Where timber is used it shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may mar the surface of concrete.

1504.11 Forms shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressure, ramming and vibration during and after placing the concrete. Screw jacks or hard wood wedges where required shall be provided to make up any settlement in the formwork either before or during the placing of concrete.

1504.12 The formwork shall ensure the correct final shape of the structure, with the calculated amount of positive or negative camber. The deformation of falsework, scaffolding or propping and the instantaneous or deferred deformation due to various causes arising in prestressed structures, shall be properly accounted for.

1504.13 Suitable camber shall be provided to horizontal members of structure, specially in long spans, to counteract the effects of deflection. The formwork shall be so fixed as to provide for such camber.

1504.14 The formwork shall be coated with an approved release agent that will effectively prevent sticking and will not stain the concrete surface. Lubricating oils (machine oils) shall be prohibited for use as coating.

1505 LINING OF FORMWORK

The formwork shall be lined with material approved by the Engineer so as to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and shall be so fixed to its backing as not to impart any blemishes. It shall be of the same type and obtained from only one source throughout for the construction of any one structure. The contractor shall make good any imperfections in the resulting finish as required by the Engineer. Internal ties and embedded metal parts shall be carefully detailed and their use shall be subject to the approval of the Engineer.

1506 PRECAUTIONS

The following precautions shall be observed:

- i) It shall be ensured that any cut-outs or openings provided in any structural member to facilitate erection of formwork, are closed with the same grade of concrete as that of the structure, after formwork is removed.
- ii) Provision for safe access to the formwork shall be made at all levels as required.
- iii) Close watch shall be maintained to check for settlement of formwork during concreting and any settlement shall be promptly rectified.
- iv) Natural ground shall be checked for bearing capacity and likely settlement before erection of the staging.
- v) it shall be ensured that water used for curing or rain water does not stagnate near the base plate of the staging.
- vi) For shutters used for deep and narrow member, temporary openings in the sides shall be provided to facilitate pouring and compaction of concrete.

1507 PREPARATION OF FORMWORK BEFORE CONCRETING

The inside surfaces of forms shall, except in the case of permanent formwork or where otherwise agreed to by the Engineer, be coated with a release agent supplied by approved manufacturer or of an approved material to prevent adhesion of concrete to the formwork. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come in contact with any reinforcement or prestressing tendons and anchorages. Different release agents shall not be used in formwork for exposed concrete.

Before re-use of forms, the following actions shall be taken :

- i) The contact surfaces of the forms shall be cleaned carefully and dried before applying a release agent.
- ii) It should be ensured that the release agent is appropriate to the surface to be coated. The same type and make of release agent shall be used throughout on similar formwork materials and different types should not be mixed.
- iii) The form surfaces shall be evenly and thinly coated with release agent. The vertical surface shall be treated before horizontal surface and any excess wiped out.
- iv) It shall be ensured that the reinforcement or the surface of the hardened concrete shall not come in contact with the release agent.

- v) All forms shall be thoroughly cleaned immediately before concreting.

The Contractor shall give the Engineer due notice before placing any concrete in the forms to permit him to inspect and approve the formwork. However, such inspection shall not relieve the contractor of his responsibility for safety of formwork, men, machinery, materials and finish or tolerances of concrete.

1508 REMOVAL OF FORMWORK

The scheme for removal of formwork (Le. de-shuttering and de-centering) shall be planned in advance and furnished to the Engineer for scrutiny and approval. No formwork or any part thereof shall be removed without prior approval of the Engineer.

The formwork shall be so removed as not to cause any damage to concrete. Centering shall be gradually and uniformly lowered in such a manner as to permit the concrete to take stresses due to its own weight uniformly and gradually to avoid any shock or vibration.

Form work shall not be released unless the concrete has achieved strength of at least twice the stress the concrete may be subjected at the time of the removal of formwork. When no test is conducted for determination of strength of concrete and where the time of removal of formwork is not specified, the same shall be as under :

a)	Walls, piers, abutments, columns and vertical faces of structural members	12 to 48 hours as may be decided by the Engineer
b)	Soffits of Slabs (with props left under)	3 days
c)	Props left under slabs	14 days
d)	Soffits of Girders (with props left under)	7 days
e)	Props (left under girders)	21 days

The above time schedule is applicable when ordinary Portland Cement is used without any admixtures at an ambient temperature exceeding 10°C.

For concrete made with Portland pozzolona cement, Portland slag cement or mineral admixtures, additional cube samples shall be taken for verifying the strength of concrete to decide the time of deshuttering.

Where there are re-entrant angles in the concrete sections, the formwork should be removed at these sections as soon as possible after the concrete has set, in order to avoid cracking due to shrinkage of concrete.

Additional precautions as given in Clause 8.17 of IRC: 87, shall also be followed.

1509 RE-USE OF FORMWORK

When the formwork is dismantled, its individual components shall be examined for damage and damaged pieces shall be removed for rectification. Such examination shall always be carried out before their use again. Before re-use all components shall be cleaned of deposits of soil, concrete or other unwanted materials. Threaded parts shall be oiled after cleaning.

All bent steel props shall be straightened before re-use. The maximum permissible deviation from straightness is $1/600$ of the length. The maximum permissible axial loads in used props shall be suitably reduced depending upon their condition. The condition of the timber components, plywood and steel shuttering plates shall be examined closely for distortion and defects before re-use.

1510 SPECIALISED FORMWORK

Specialised formwork such as slipform, floating caisson and travelling form, wherever used shall be designed and detailed by competent agencies and a set of complete working drawings and installation instructions supplied to the Engineer. In case proprietary equipment is used, the supplier shall furnish drawings, details, installation instructions etc, in the form of manuals along with the formwork.

For slipform, the rate of climb of the formwork shall be designed for each individual case taking into account various parameters including the grade of concrete, concrete strength, concrete temperature, ambient temperature and concrete admixtures.

For floating caisson, the details of fabrication, floating to site and placing in position shall be as given in Clause 1203.5 of these Specifications.

In order to verify the time and sequence of striking/removal of specialised formwork, routine field tests for the consistency and strength development of concrete are mandatory.

For specialised formwork, the form lining material may be either plywood or steel sheet of appropriate thickness.

1511 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1718 MEASUREMENTS FOR PAYMENT

Structural concrete shall be measured in **cubic metres** basis with finished work. In reinforced or prestressed concrete, the volume occupied by reinforcement or prestressing

cables and sheathing shall not be deducted. The slab shall be measured as running continuously through and the beam as the portion below the slab.

1719 RATE

The contract unit rate for structural concrete shall cover costs of all materials, labour, tools, plant and equipment required for mixing, transporting and placing in position, vibrating and compacting, finishing and curing as per this Section or as directed by the Engineer, including all incidental expenses, sampling and testing, quality assurance and supervision. Unless mentioned separately as an item in the contract, the contract unit rate for concrete shall also include the cost of providing, fixing and removing formwork required for concrete work as per **Section 1500** of these Specifications.

"The rate of R.C.C. bored piles shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

If the concrete is found to be acceptable by the Engineer as sub-standard work, the Contractor shall be subjected to reduction in his contract unit rate. For deficiency in compressive strength of concrete when accepted by the Engineer, the reduction in rate shall be applied as under:

$$\text{Percentage reduction in rate} = \frac{\text{Design Strength} - \text{Observed Strength}}{\text{Design Strength}} \times 100$$

Item No.5:- Providing steel Liner for pile including fabricating and setting out as per detailed drawing as directed.

This work shall include furnishing, fabricating, transporting, and erecting 6 mm thick MS liner for cast in situ concrete piles in conformity with the drawings and these specifications or as desired by the Engineer.

General requirements relating to the supply of material shall conform to the specifications of IS: 1387. Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth and uniform finish and shall be straightened in the mill before shipment. They shall also be free from loose mill scale, rust, pits or other defects affecting its strength and durability.

MS liner shall conform to relevant Section 1000 of MORT&H specifications

MS liner shall be provided for casing length at the top. A minimum of 3.0 m length of top of bore shall invariably be provided with casing to ensure against loose soil falling into the bore. The casing will be left in position permanently specially in cases where- the aggressive action of the ground water is to be avoided, or in the cases of piles built in water or in cases where significant length of piles could be exposed due to scour.

MS liner shall be suitable for cast in situ pile. It shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the length shown on the drawing or as approved by the Engineer.

The measurement of MS liner shall be by weight in **M.T** that remains in the finished structure complete in place, limited to that shown on drawings or ordered by the Engineer.

"The rate of steel Liner for pile shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

The contract unit rate for permanent steel liners shall include cost of all labour, fabrication and placing the steel liner to the required depth as shown on the drawings and as ordered by the Engineer.

Item No.6:- Load testing of foundation piles including loading with necessary kentledge or any other suitable method as directed.

1. Piles find application in foundation to transfer loads from a structure to competent subsurface strata having adequate load bearing capacity. The load transfer mechanism from a pile to the surrounding ground is complicated and could not yet be fully ascertained, although application of piled foundations is in practice over many decades. Broadly, piles transfer axial loads either substantially by skin friction along its shaft or substantially by the end bearing. Piles are used where either of the above load transfer mechanism is possible depending upon the subsoil stratification at a particular site. Construction of pile foundations require a careful choice of piling system depending upon the subsoil

conditions, the load characteristics of a structure and the limitations of total settlement, differential settlement and any other special requirement of a project. The installation of piles demands careful control on position, alignment, depth and involve specialized skill and experience.

Pile load test is the most direct method for determining the safe loads on piles including its structural capacity with respect to soil in which it is installed. It is considered more reliable on account of its being in-situ test than the capacities computed by other methods, such as static formula, dynamic formulae and penetration test data. There are widely varying practices followed for load tests on piles. Particularly, the difficulties regarding the establishment of an acceptable criterion, for determining the ultimate and safe bearing capacity of piles, and predicting the pile group behaviour from the test data obtained from individual load test on single piles, cannot be under-estimated as the factors affecting are many. However, an attempt is made to bring out an unified approach to the various aspect of load test on piles.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Cut-Off Level — The level where the installed pile is cut-off to support the pile caps or beams or any other structural components at that level.

2.2 Datum Bar — A rigid bar placed on immovable supports.

2.3 Factor of Safety — The ratio of the ultimate load capacity of a pile to the safe load of a pile.

2.4 Initial Test — It is carried with a view to determine ultimate load capacity and the safe load capacity.

2.5 Kentledge — Dead-weight used for applying a test load on piles.

2.6 Net Displacement — Net movement of the pile top from the original position after the pile has been subjected to a test load and subsequently released.

2.7 Routine Test — It is carried out on a working pile with a view to check whether pile is capable of taking the working load assigned to it.

2.8 Test Pile — A pile which is meant for initial test.

2.9 Total Displacement (Gross) — The total movement of the pile top under a given load.

2.10 Total Elastic Displacement — This is magnitude of the displacement of the pile due to rebound caused at the top after removal of a given test load. This comprises two components as follows:

- a) Elastic displacement of the soil participating in load transfer, and
- b) Elastic displacement of the pile shaft.

2.11 Ultimate Load Capacity — The maximum load which a pile or pile shaft can carry before failure of ground (when the soil fails by shear as evidenced from the load settlement curves) or failure of pile.

2.12 Safe Load — It is a load on a pile derived by applying a factor of safety on ultimate load capacity of pile as determined by load test.

2.13 Working Load — The load assigned to a pile according to design.

2.14 Working Pile — A pile forming part of foundation of a structural system which may be used for routine load test.

3. NECESSARY INFORMATION

3.1 The following information is necessary for pile(s) on which test is proposed:

- a) Pile type including material and reinforcement details, group of piles, if any;
- b) Method of driving with driving record or installation;
- c) Pile depth(s) and details of cross-section(s);
- d) Type of test desired;

- e) Layout of the pile(s) — space available around and position in the group for single pile test;
- f) Depth of water table and soil strata details with soil test results;
- g) Safe load and ultimate load capacity, and the method(s) on which based;
- h) Availability and provision of type of piles or anchors or kentledge for reaction;
- j) Nature of loading/loading plan with a particularly mention of pile(s) which may be free standing when scour is expected; and
- k) Any other information concerning planning and conducting the tests including the relevant past experience concerning similar test(s).

4. TYPES OF TESTS

4.1 There are two types of tests for each type of loading (that is, vertical, lateral and pullout), namely, initial and routine test.

4.2 Initial Test — This test is required for one or more of the following purposes. This is done in case of important and/or major projects and number of tests may be one or more depending upon the number of piles required.

NOTE — In case specific information about strata and past guiding experience is not available, there should be a minimum of two tests.

- a) Determination of ultimate load capacities and arrival at safe load by application of factor of safety,
- b) To provide guidelines for setting up the limits of acceptance for routine tests,
- c) To study the effect of piling on adjacent existing structures and take decision for the suitability of type of piles to be used,
- d) To get an idea of suitability of piling system, and
- e) To have a check on calculated load by dynamic or static approaches.

5 GENERAL REQUIREMENTS APPLICABLE TO ALL TYPES OF TESTS

5.1 Pile test may be carried out on a single pile or a group of piles as required. In case of pile groups, caps will be provided such that the required conditions of actual use are fulfilled.

5.2 Generally the load application and deflection observation will be made at the pile top.

5.3 In particular cases where upper part of pile is likely to be exposed later on due to scour, dredging or otherwise then capacity contributed by that portion of the pile during load test shall be duly accounted for. The pile groups in these conditions shall be tested without their cap resting on the ground.

5.4 The test should be carried out at cut-off level wherever practicable, otherwise suitable allowance shall be made in the interpretation of the test results/test load if the test is not carried out at cut-off level.

This work shall include carrying out Initial pile load test on test piles which are not to be incorporated in the work. The methodology of carrying out load tests and of arriving at safe load on piles shall conform to IS:2911 (Part IV).

1. Load test may be carried out as decided by the Engineer-in-charge on one or more working piles. Preloading shall be not less than one and a half times the estimated safe load carrying capacity of the pile in case of sandy soils and two times the estimated safe load in the case of clayey soils.
2. The test shall commence as early as possible after casting/driving of the piles.

The test shall be carried out by applying a series of load on R.C.C. Cap over a pile or a group of piles unaided by any other support. The load shall preferably be applied by means of hydraulic jack reacting against a loaded platform or against heavy R.S. Joists or a suitable load frame held down by anchor piles or other anchorages, which shall be pre-loaded to not less than one and-a-half times the estimated safe load carrying capacity of the pile. The load applied by the jack should be co-axial with the test pile. Wherever tension piles or other suitable anchors are used to sustain the loaded platform, the centre distance between the test pile and anchor pile should be minimum of 5 times the test pile diameter. The hydraulic jack used shall be of adequate capacity and shall have a pressure gauge and a remote control pump.

3. Before load test is performed, the proposed set up and the load frame shall be got approved from the Engineer-in-charge. Readings of settlement and.

rebound shall be recorded with the help of at least two dial gauges (preferably four) of 0.02 mm. sensitivity and resting on a diametrically opposite ends of the pile cap. The dial gauges shall be fixed in a datum bar whose ends rest upon non-movable supports. The supports for datum bar with reference to which the settlement of the pile would be measured shall be at least 5 'd' away, clear from the piles, where 'd' is the diameter of the pile subject to a minimum of 2 meters for good sandy soils and 5 meters for loose soils.

4. The test load shall be applied in equal increments of about one fifth of the estimated safe load and reduced to smaller increments at the final stages as or directed by the Engineer-in-charge. Alternate loading and unloading of each load increment shall be performed and the elastic and plastic settlement recorded.

5. Each stage of loading or unloading shall be maintained till the rate of movement of the pile top is not more than 0.02 mm. per hour in case of clay soil and 0.1 mm. per hour for sandy soil.

6. The loading shall be continued upto 1 1/2 times the estimated safe load on the pile or when the total settlement of pile top/cap equals the value specified below.

Assessment of safe load shall be as under:

(a) Two-thirds of the final load at which the total settlement attain a value of 12 mm unless it is established that a total settlement different from 12 mm. is permissible in a given case on the basis of nature and type of the structure, in the latter case the actual total settlement permissible shall be used for assessing the safe load instead of 12 mm.

(b) For a group of piles, two-thirds of the final load at which the total settlement attains a value of 40 mm.

7. Lateral load test:-This test shall be carried out at the cut off level of the piles, Two or more test pile which may be part of the working piles driven to the required depth and spacing shall be used for the tests. The lateral load at the cut off level shall either be applied by a jack inserted between the piles or by some other arrangement capable of facilitating the application of desired pull.

The loading shall be applied in increments of about 20 percent of the estimated safe load, reducing to smaller increments in the final stages of the test. The next increment shall be applied after the rate of displacement is about 0.05 mm. per hour in sandy soils and 0.02 mm. per hour in clayey soils or two hours whichever is earlier.

Lateral displacement shall be recorded by using at least two dial gauges spaced at 30 cm and kept horizontally one above the other on each pile. Where it is not possible to locate the dial gauges in line of the jack axis, then the two dial gauges be kept at a distance of 30 cm. at a suitable height and the displacement at load point, interpolated from similar triangles.

The safe lateral load on the pile shall be taken as the least of the following

- (a) 50 per cent of the final load at which total displacement increases to 12 mm.
- (b) Final load at which total displacement corresponds to 5 mm and.
- (c) Load corresponding to any other specified displacement due to performance requirements.

8. The measurement for payment shall be divided in **tonne.** of load test on piles.

9. The Unit includes all materials, labour, equipment plant, platform and gauges for the purpose of recording result to complete the job.

Item No.7:- Conducting Pile low strain integrity test as per ASTM D 5882- 96 code of American Society for Testing on cast -in situ RCC pile of 1200 mm diameter inclusive of analysis with all contractor's equipment, manpower, site preparation, lead and lifts etc. complete as per standard procedure, and as directed by the Engineer in charge.
Note:- Rate is inclusive All equipment, All labour and consumable required & Mobilization of equipment.

PILE INTEGRITY TEST

1. General Remarks

Pile Integrity Testing (PIT) is a Non Destructive integrity test method for foundation piles. It is a "Low Strain" Method (since it requires the impact of only a small handheld hammer). The evaluation of PIT records is conducted either according to the Pulse Echo (or Sonic Echo – a time domain analysis) or the Transient Response (frequency domain analysis) Procedure. This test is standardized by ASTM D5882 Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations. Pile Integrity Test is performed to check that a pile is free of major cracks and voids, prior to construction of the super-structure.

2. Scope

2.1 This test method covers the procedure for determining the integrity of individual vertical or inclined piles by measuring and analyzing the velocity (required) and force (optional) response of the pile induced by an (hand held hammer or other similar type) impact device usually applied axially and perpendicularly to the pile head surface. This test method is applicable to long structural elements that function in a manner similar to any deep foundation units (such as driven piles, augured piles, or drilled shafts), regardless of their method of installation provided that they are receptive to low strain impact testing.

2.2 This standard provides minimum requirements for low strain impact testing of piles. Plans, specifications, and/or provisions prepared by a qualified engineer, and approved by the agency requiring the test(s), may provide additional requirements and procedures as needed to satisfy the objectives of a particular test program.

2.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Code of Practice ASTM D 6026.

2.5 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Note:

The quality of the result produced by this test method is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing/ sampling/ inspection/etc. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

3. Description of Method

Low Strain Integrity Testing may be applied to any concreted pile (e.g. concrete piles, drilled shafts, augured cast in place piles, concrete filled pipe piles). The test requires the impact of a small hand held hammer on the shaft top and the measurement of the shaft top motion (acceleration or velocity). The input compression wave from the hammer is reflected from pile toe (or a change in cross sectional area or pile material quality) and returns to the pile top at a time related to the speed of travel of the wave in the pile material.

The pile top velocity is displayed as a function of time with an exponentially increasing magnitude such that the pile toe reflection is enhanced. The averaged, amplified velocity, averaged for several impacts, is the standard result of the Pulse Echo Method. The force as a function of time, if available, provides additional information as to the pile quality near the pile top.

The Transient Response Method result shows the ratio of velocity to force transforms for all relevant frequencies in a plot called Mobility. It should be shown together with the related low frequency pile stiffness. Transient Response requires that hammer force is measured.

4. Test Equipment

Provide a Pile Integrity Tester (PIT) or an equivalent equipment. following minimum requirements:

The analog to digital resolution shall be at least 24 bits.

The sampling frequency shall be at least 25,000 Hz.

Data shall be stored such that additional processing or further wave analysis is possible.

Data shall be displayed in the field for evaluations of preliminary data quality and interpretation.

The equipment shall allow attachment of a motion sensing device capable of measuring acceleration, velocity or displacement due to the impact of the pile top with a hand held hammer.

The equipment shall have the PIT (Pile Integrity Tester) performs the wave equation based nondestructive test known as Pulse or Sonic Echo Test, or a Low Strain Dynamic Test.

The PIT test consists of attaching one or two accelerometers to the foundation, and using a hand held hammer to impact it. The PIT collects the acceleration data and displays curves that reveal any significant changes in cross section that

may exist along the pile. The software post processes the data and generates reports, while the software simulates a PIT test and performs simplified signal matching to assess the shape of the pile.

5. Test Personnel

The field testing shall be performed by an experienced technician with at least one year experience in integrity testing. The interpretation of the records requires extensive experience by a graduated engineer with a at least Three years experience in integrity testing.

6. Test Preparation

For the cast in place piles, integrity testing shall not be performed until the concrete has cured for a minimum of seven (7) days unless otherwise approved by the engineer. The pile head shall be free from water, dirt or other debris. The concrete at the pile top surface must be relatively smooth and provide sufficient space for attaching the motion sensing device and for the hammer impact area.

50% of total piles shall be integrity tested. The location of piles for designated for integrity testing shall be specified by the engineer after pile installation. Additional piles may be selected for testing at the discretion of the engineer if circumstances either during or after pile installation should make a piles' integrity suspect, or if the initial tests reveal major defects.

7. Result Presentation

The testing engineer shall present a report 5 working days after performing the field test to provide the final test results and integrity evaluation. For each pile tested, the averaged, amplified velocity versus time record shall be included in the report, with a table summarizing results and conclusions. Additional plots and analyses can be included as required or suggested by the testing engineer.

8. Acceptance and Rejection

Shafts with no significant reflections from locations above the pile toe and with a clear pile toe reflection may be accepted. Where no clear toe reflection is apparent, the experienced test engineer shall state to which shaft depth the test appears to be conclusive. Where reflections from locations with significant reductions in pile area or pile material strength or stiffness above the pile toe are observed, the pile has a serious defect. If the record is complex, the results may be deemed inconclusive. Construction records (concrete usage, grout pressure records, soil

borings) may be valuable in result interpretations or additional numerical analysis modeling may be used to quantify the record. The decision to reject and replace, or repair, any defective shaft is at the sole responsibility of the engineer of record for the foundation.

9. Remedial Action

Rejected or questionable piles may be replaced. Questionable piles may also be subjected to further testing, e.g., static load testing, dynamic load testing, core drilling, ultrasonic logging, etc. Remedial action may include pressure grouting through core holes. If the pile top appears questionable, further pile top cutoff and retesting may be advisable. If a majority of piles diagnose as "inconclusive", partial or even complete pile excavation or another test method may be necessary for pile acceptance.

Related ASTM Standards

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D6026 Practice for using significant digits in Geotechnical Data.

10. The rate shall be for a unit of **EACH**.

Item No.8:- Dynamic Load testing of foundation piles including loading with necessary kentledge or any other suitable method as directed.

1. Piles find application in foundation to transfer loads from a structure to competent subsurface strata having adequate load bearing capacity. The load transfer mechanism from a pile to the surrounding ground is complicated and could not yet be fully ascertained, although the application of piled foundations is in practice over many decades. Broadly, piles transfer axial loads either substantially by skin friction along its shaft or substantially by the end bearing. Piles are used where either of the above load transfer mechanism is possible depending upon the subsoil stratification at a particular site. Construction of pile foundations require a careful choice of piling system depending upon the subsoil conditions, the load characteristics of a structure and the limitations of total settlement, differential settlement and any other special requirement of a

project. The installation of piles demands careful control on position, alignment, depth and involve specialized skill and experience.

Pile load test is the most direct method for determining the safe loads on piles including its structural capacity with respect to soil in which it is installed. It is considered more reliable on account of its being in-situ test than the capacities computed by other methods, such as static formula, dynamic formulae and penetration test data. There are widely varying practices followed for load tests on piles. Particularly, the difficulties regarding the establishment of an acceptable criterion, for determining the ultimate and safe bearing capacity of piles, and predicting the pile group behavior from the test data obtained from individual load test on single piles, cannot be under-estimated as the factors affecting are many. However, an attempt is made to bring out an unified approach to the various aspect of load test on piles.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Cut-Off Level — The level where the installed pile is cut-off to support the pile caps or beams or any other structural components at that level.

2.2 Datum Bar — A rigid bar placed on immovable supports.

2.3 Factor of Safety — The ratio of the ultimate load capacity of a pile to the safe load of a pile.

2.4 Initial Test — It is carried with a view to determine ultimate load capacity and the safe load capacity.

2.5 Kentledge — Dead-weight used for applying a test load on piles.

2.6 Net Displacement — Net movement of the pile top from the original position after the pile has been subjected to a test load and subsequently released.

2.7 Routine Test — It is carried out on a working pile with a view to check whether pile is capable of taking the working load assigned to it.

2.8 Test Pile — A pile which is meant for initial test.

2.9 Total Displacement (Gross) — The total movement of the pile top under a given load.

2.10 Total Elastic Displacement — This is magnitude of the displacement of the pile due to rebound caused at the top after removal of a given test load. This comprises two components as follows:

- a) Elastic displacement of the soil participating in load transfer, and
- b) Elastic displacement of the pile shaft.

2.11 Ultimate Load Capacity — The maximum load which a pile or pile shaft can carry before failure of ground (when the soil fails by shear as evidenced from the load settlement curves) or failure of pile.

2.12 Safe Load — It is a load on a pile derived by applying a factor of safety on ultimate load capacity of pile as determined by load test.

2.13 Working Load — The load assigned to a pile according to design.

2.14 Working Pile — A pile forming part of foundation of a structural system which may be used for routine load test.

3. NECESSARY INFORMATION

3.1 The following information is necessary for pile(s) on which test is proposed:

- a) Pile type including material and reinforcement details, group of piles, if any;
- b) Method of driving with driving record or installation;
- c) Pile depth(s) and details of cross-section(s);
- d) Type of test desired;
- e) Layout of the pile(s) — space available around and position in the group for single pile test;
- f) Depth of water table and soil strata details with soil test results;

- g) Safe load and ultimate load capacity, and the method(s) on which based;
- h) Availability and provision of type of piles or anchors or kentledge for reaction;
- j) Nature of loading/loading plan with a particularly mention of pile(s) which may be free standing when scour is expected; and
- k) Any other information concerning planning and conducting the tests including the relevant past experience concerning similar test(s).

4. TYPES OF TESTS

4.1 There are two types of tests for each type of loading (that is, vertical, lateral and pullout), namely, initial and routine test.

4.2 Routine Test — This test is required for one or more of the following purposes. The number of tests may generally be one-half percent of the total number of piles required. The number of the test may be increased up to 2 percent in a particular case depending upon nature, type of structure and strata condition:

- One of the criteria to determine the safe load of the pile;
- Checking safe load and extent of safety for the specific functional
- requirement of the pile at working load.

NOTE — In case specific information about strata and past guiding experience is not available, there should be a minimum of two tests.

- a) Determination of ultimate load capacities and arrival at safe load by application of factor of safety,
- b) To provide guidelines for setting up the limits of acceptance for routine tests,
- c) To study the effect of piling on adjacent existing structures and take decision for the suitability of type of piles to be used,
- d) To get an idea of suitability of piling system, and

- e) To have a check on calculated load by dynamic or static approaches.

5 GENERAL REQUIREMENTS APPLICABLE TO ALL TYPES OF TESTS

5.1 Pile test may be carried out on a single pile or a group of piles as required. In case of pile groups, caps will be provided such that the required conditions of actual use are fulfilled.

5.2 Generally the load application and deflection observation will be made at the pile top.

5.3 In particular cases where upper part of pile is likely to be exposed later on due to scour, dredging or otherwise then capacity contributed by that portion of the pile during load test shall be duly accounted for. The pile groups in these conditions shall be tested without their cap resting on the ground.

5.4 The test should be carried out at cut-off level wherever practicable, otherwise suitable allowance shall be made in the interpretation of the test results/test load if the test is not carried out at cut-off level.

The contractor shall be required to carry out routine load tests as directed by the Engineer-in-charge on an individual pile or on a group of piles or on both. The routine load tests shall be carried out generally as per IS 2911 (Part-IV). Report on routine load tests shall be submitted in an approved format for Department's approval at no extra cost. In case the tests on the routine piles reveal safe capacity less than specified, the contractor shall, at his own cost, provide suitable modifications to the pile or other remedial measures after obtaining approval of the Engineer-in-Charge. In case of an unsatisfactory results being revealed on any routine tests it shall be the contractor's responsibility to carry out additional routine tests, at his own cost till the criteria laid down are fulfilled.

Rate for routine load test shall be inclusive of providing kentledges, making other arrangements for the test loading platforms, providing tools and plants, equipments like hydraulic jack, dial gauges etc. other measuring instruments and all labour involved in carrying out tests.

The measurement for payment shall be per **Nos.** of load test on piles.

The Unit includes all materials, labour, equipment plant, platform and gauges for the purpose of recording result to complete the job.

Item No.9:- Providing & filling in foundation with ordinary cement concrete M 15 mix and providing necessary vertical pin headers including formwork vibrating ramming & curing complete.

Ordinary cement concrete of specified Grade shall be carried out in accordance with the following specification.

1. In case of ordinary concrete, mix is not required to be designed by preliminary tests and proportions of cement, fine aggregates and coarse aggregates are specified by volume as given in table below for different grades of concrete designated as ordinary M. 10, M. 15, M.20 and M.25.
2. In the designation of a concrete mix, letter "M" refers to the mix and the number the specified 28 days works cube compressive strength of that mix on 150 mm. cubes expressed in kg/cm².
3. The ordinary concrete mix shall generally be specified by volume. For cement which normally comes in bags and is used by weight, volume shall be worked out taking 50 kg. of cement as 0.035 cubic meter in volume. While measuring aggregate by volume, shaking, ramming or hammering shall not be done. Proportioning of sand shall be as per its dry volume. In case it is dump, allowance for "bulking" shall be made as per IS : 2386 (Part-III).
4. Ingredients required for ordinary concrete containing one 50 Kg. bag of cement of different proportions of mix shall be as given in Table below.

TABLE

Grade of Concrete	Mix By Volume	Total Quantity of dry aggregates by volume per 50 Kg. of cement, to be taken as sum of the individual volumes of fine and coarse aggregates max	Proportion of fine aggregate to coarse aggregate	Quantity of water per 50 kg. of cement max.
1	2	3	4	5
(1 Cubic meter = 1000 liters)				
Ordinary	Liters			Liters

M.10	1:3:6	300	General 1:2 for fine aggregate to coarse aggregate by volume but subject to a upper limit of 1:1. ½ & a lower limit of 1:3	34
M.15	1:2:4	220		32
M.20	1:1.1/ 2:3	160		30
M.25	1:1:2	100		27

NOTE- The proportions of the aggregates shall be adjusted from upper limit to lower limit progressively as the grading of the fine aggregates becomes finer & the maximum size of coarse aggregate becomes larger.

Example- For an average grading of fine aggregate (that is Zone II of IS : 383-1963) the proportions shall be 1: 11/2, 1:2 and 1:3 for maximum size of aggregates 10 mm, 20 mm. and 40 mm. respectively (after carrying out sieve analysis).

Note-2 A mix leaner than M.100 (1:3:6) may be used for non- structural parts, if provided in the contract. In such case grading of aggregates shall be by volume. Other requirements for mixing, placing & curing shall be the same.

5. Following shall be the maximum nominal size of coarse aggregate for the different items of work:

Sr. No.	Item of Construction	Maximum nominal size of Coarse aggregate
(i)	R.C.C. well curb and R.C.C. Piles	40 mm
(ii)	R.C.C. well staining	63 mm
(iii)	Well cap or pile cap; solid type piers, abutment and wing-walls, and their pier caps	40 mm
(iv)	R.C.C. works in cross girders deck slab, wearing coats, kerb, light posts, blast walls, approach slab etc. and hollow type piers, abutments, wing-walls and their pier caps	20 mm
(v)	R.C.C. bearings.	20 mm.
(vi)	For any other item of construction not covered by items (i) to (v)	As specified on the drawing or as desired

		by the Engineer-In-charge in case it is not specified on drawing.
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For heavily reinforced concrete members as in the case of ribs of main beams nominal maximum size of aggregate shall usually be restricted to 5 mm. less than the minimum lateral clear distance between the main bars or 5 mm. less than the minimum cover to the reinforcement, whichever is the smaller.

6. Fine aggregate shall be clean, hard, coarse sand. It shall be free from dust and such other substances. The sand be got approved by the Engineer-in-charge.

7. All materials shall be stored as to prevent their deterioration or intrusion of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Engineer-in-charge shall not be used in the works.

8. Cement shall be stored above the ground level in perfectly dry and water tight sheds. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirements at site and should be cleaned at least once every 3 to 4 months. The aggregate shall be stored in such a way as to prevent admixture of foreign materials. Different size of fine or coarse aggregate shall be stored in separate stock-piles sufficiently away from the each other to prevent intermixing the materials.

9. The water for mixing shall be potable water to satisfaction of the Engineer-in-charge. The quantity of water shall be just sufficient to produce a dense concrete of required workability for the job.

10. For all work concrete shall be mixed in a mechanical mixer which along with other accessories shall be kept in first class working condition and so maintained throughout the construction. Mixing shall be continued till materials are uniformly distributed and uniform colour of the entire mass is obtained and each individual particle of the coarse aggregate show complete coating of mortar containing its proportionate amount of cement. In no case shall the mixing be done for less than 2 minutes after all ingredients have been put into the mixer.

11. When hand mixing is permitted by the Engineer-in-charge for small jobs or for certain other reasons. It shall be done on a smooth watertight platform large enough to allow efficient turning over of the ingredients of concrete before and after adding water. Mixing platform shall be so arranged that no foreign material shall get mixed with concrete nor does the mixing water flow out. Cement in

required number of bags shall be placed in a uniform layer on top of the measured quantity of fine and coarse aggregate, which shall also be spread in a layer of uniform thickness on the mixing platform. Dry coarse and fine aggregate and cement shall then be mixed thoroughly by turning over to get a mixture of uniform colour. Enough water shall then be added gradually through a rose can and the mass turned over till a mix of required consistency is obtained. In hand mixing quantity of cement shall be increased by 10 per cent above that specified.

12. Mixers which have been-out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch. Unless otherwise agreed to be the Engineer-in-charge, the first batch of concrete from the mixer shall contain only two thirds of normal quantity of coarse aggregate. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

13. The method of transporting and placing concrete shall be approved by the Engineering-in-charge. Concrete shall be so transported and placed that no contamination, segregation or loss of its constituent material takes places. All form work and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete. No concrete shall be placed in any part of the structure until the approval of the Engineer-in-charge has been obtained.

14. If concreting is not started within 24 hours of the approval being given, it shall have to be obtained again from the Engineer-in-charge. Concreting being given, it shall proceed continuously over the area between construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a proper construction joint is formed. Concrete shall be compacted in its final position within 30 minutes of its discharge from the mixer unless carried in properly design agitators, operating continuously, when this time shall be within 2 hours of the addition of cement to the mix and within 30 minutes of its discharge from the agitator. Except where otherwise agreed to be the Engineer-in-charge, concrete shall be deposited in horizontal layers to a compacted depth of not more than 0.45 meter when internal vibrators are used and not exceeding 0.30 meter in all other cases.

15. Unless otherwise agreed to by the Engineer-in-charge concrete shall not be dropped into place from a height exceeding 1.2 meters. When trucking or chutes are used they shall be kept clean and used in such a way as to avoid segregation. When concreting has to be resumed on a surface which has hardened, it shall be roughened, swept, clean, thoroughly wetted and covered with a 13 mm. thick layer

of mortar composed of cement and sand in the same ratio as in the concrete mix itself. This 13 mm. layer of mortar shall be freshly mixed and placed immediately before placing of new concrete. Where concrete has not fully hardened, all laitance shall be removed by scrubbing the well surface with wire or bristle brushes, care being taken to avoid dislodgement of any particles of coarse aggregate. The surface shall then be thoroughly wetted, all free water removed and then coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 150 mm. in thickness, and shall be well rammed against old work particular attention being given to corners and close spots.

16. All concrete shall be compacted to produce a dense homogeneous mass with the assistance of vibrators, unless otherwise permitted by the Engineer-in-charge for exceptional cases, such as concreting under water, where vibrators cannot be used. Sufficient vibrators in serviceable condition shall be kept at site so that spare equipment is always available in the event of break downs.

17. Immediately after compaction, concrete shall be protected against harmful effects of weather, including rain, running water, shocks, vibration, traffic, rapid temperature changes, frost and driving out process. It shall be covered with wet sacking, hessian or other similar absorbent material approved by the Engineer-in-charge soon after the initial set, and shall be kept continuously wet for a period of not less than 14 days from the date of placement. Masonry work over the foundation concrete may be started after 48 hours of its laying but the curing of concrete shall be continued for a minimum period of 14 days.

18. Form work shall include all temporary or permanent forms required for forming the concrete, together with all temporary construction required for their support. Form work shall however be divided into following two distinct categories:-

(1) Shuttering i.e., form work required for forming the concrete.

(2) Scaffolding i.e., form-work required for supporting shuttering.

Forms for shuttering shall be constructed only in metal suitably lined. Forms for scaffolding shall be constructed of metal or timber. Both shuttering and scaffolding shall be of substantial-rigid construction and shuttering shall be true to shape and dimensions shown on the drawings. All bolts and rivets shall be counter-sunk and well ground to provide a smooth, plane surface.

19. Forms shall be mortar-tight and shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports, They shall be strong enough to withstand all pressure, ramming and vibration, without

deflection from the prescribe lines occurring during and after placing the concrete. Screw jacks or hard wood wedges where required shall be provided to make up any settlement in the formwork either before or during the placing of concrete. Suitable camber shall be provided in horizontal members of structure, specially in long spans to counteract the effects of any fixed as to provide for such camber. Forms shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections. Unless otherwise specified or directed, chambers or fillets of sizes 25 mm x 25 mm shall be provided at all angles of formwork to avoid sharp corners.

20. The inside surfaces of shuttering shall, except in the case of permanent form work or where otherwise agreed to by the Engineer-in-charge, be coated with an approved material to prevent adhesion of concrete to the form work. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come into contact with any reinforcement or pre-stressing tendons and anchorages. Different release agents shall not be used in form work for concrete which will be visible in the finished works.

21. Special measures shall be taken to ensure that the form work does not hinder the shrinkage of concrete because without these cracking could occur before the formwork is removed. Where ever applicable arrangements must be made to ensure that the form work does not restrain the shortening and hogging of the beams or slabs during tensioning of the tendon's. The form work should take due account of the calculated amount of positive or negative camber so as to ensure the correct final shape of the structures having regard to the deformation of a false work, scaffolding or propping and the instantaneous or deferred deformation due to various causes affecting pre-stressed structures. Where there are re-entrant angles in the concrete sections the form work should be removed, at those sections as soon as possible after the concrete has set in order to avoid cracking due to shrinkage of concrete. Form work shall be tight enough to prevent any appreciable loss of cement during vibrations, suitable tolerances should be provided in the form work. Immediately before concreting all forms shall be thoroughly cleaned. Contractor shall give the Engineer-in-charge due notice before pairing any concrete in the forms to permit him to inspect and accept the false work and forms as to their strength alignment and general fitness, but such inspection shall not relieve the contractor of his responsibility for safety of men, machinery, materials and for results obtained.

22. The Engineer- in-charge shall be informed in advance by the contractor of his intention to strike any formwork. While fixing the time for removal of formwork, due consideration shall be given to local conditions, character of the structure, the weather and other conditions that influence the setting of concrete and of the materials used in the mix. Where field operations are controlled by strength tests of concrete, the removal of the load-supporting or soffit forms may commence when concrete has attained strength equal to at least twice the stress to which the concrete will be subjected at the time of striking props including the effect of any further addition of loads.

When field operations are not controlled by strength tests of concrete the vertical forms of beams, columns and walls may be removed after 2 days. The props of slabs and beams may be removed after 14 and 21 days respectively. All formwork shall be removed without causing any damage to the concrete.

Centering shall be gradually and uniformly lowered in such a manner as to permit the concrete to take stresses due to its own weight uniformly and gradually. Where internal metal ties are permitted, they or their removable parts shall be extracted without causing any damage to the concrete and remaining holes filled with mortar. No permanently embedded metal part shall have less than 25 mm. cover to the finished concrete surface. Where it is intended to reuse the formwork, it shall be cleaned and made good to the satisfaction, of the Engineer-in-charge.

23. Immediately after the removal of forms, all exposed bars or bolts passing through the Cement concrete member and used for shuttering or any other purpose shall be cut inside the cement concrete member to a depth of at least 25 mm. below the surface of the concrete and the resulting holes be filled by cement mortar.

All fins caused by form joints, all cavities produced by the removal of form ties and all other holes and depressions, honey comb spots, broken edges or corners and other defects, shall be thoroughly cleaned, saturated with water and carefully pointed and rendered true with mortar of cement and fine aggregate mixed in the proportions used in the grade of concrete that is being finished and of as dry as consistency as is possible to use. Considerable pressure shall be applied in filling and pointing to ensure thorough filling in all voids.

Surfaces which have been pointed shall be kept moist for a period of twenty four hours. If rock pockets/honeycombs, in the opinion of the Engineer-in-charge are of such an extent or character as to affect the strength of the structure

materially or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the portions of the structure affected.

24. In the case of reinforced concrete work workability shall be such that the concrete surrounds and properly grips all reinforcement. The degree of consistency, which shall depend upon the nature of work and methods of vibration of concrete shall be determined by regular slump tests. Following slump shall be adopted for different types of works.

Type of Work		Slumps	
		Where vibrators are used	Where vibrators are not used
1	Mass concrete in RCC foundations, footings and retaining walls	10 mm to 25 mm	80 mm
2	Beams, slabs and columns simply reinforced.	25mm to 40 mm	100 to 120 mm
3	Thin R.C.C. section or section with congested steel	75 mm to 125 mm	125mm to 150mm

25. Works strength tests shall be made in accordance with IS : 516. Each test shall be conducted on ten specimens, five of which shall be tested at seven days and the remaining five at 28 days The samples of concrete shall be taken on each day of concreting and cubes shall be made at the rate of one for every 5 cubic meter of concrete or a part thereof. However, if concreting done in a day is less than 15 cubic meter, the minimum number of cubes can be reduced to 6 with the specific permission of the Engineer-in-charge. Similar works tests shall be carried out whenever the quality and grading of materials is changed irrespective of the quantity of concrete poured. The number of specimens may be suitably increased

as deemed necessary by the Engineer-in-charge when procedure of tests given above reveal a poor quality of concrete and in other special cases.

26. The average strength of the group of cubes cast for each day shall not be less than the specified works cube-strength.

27 R.C.C. work shall have exposed concrete surface. Centering design and its erection shall be approved by the Engineer-in-charge. One carpenter with helper will invariably be kept present throughout the period of concreting. Movement of labour and other persons shall be totally prohibited over reinforcement laid in position. For access to different parts, suitable mobile platforms shall be provided so that steel reinforcement in position is not disturbed. For ensuring proper cover, mortar blocks of suitable size shall be cast and tied to the reinforcement. Timber, kapchi or metal pieces shall not be used for this purpose. Concreting of important structural members shall always be done in the presence and under the supervision of departmental person not below the rank of Asstt. Engineer/ Addl. Asstt. Engineer, Overseer or as instructed by the Engineer-in-charge. After removal of form work checks that concrete produced is of good quality plastering shall not be allowed to the exposed faces of concrete.

28. In reinforced concrete the volume occupied by reinforcement shall not be deducted. The slab shall be measured as running continuously through and the beam as the portion below the slab.

29. The Anchor bar shall be providing and supplying heavy duty Rebar with a pre-defined ratio (3:1) of resin and hardener in a soft foil pack of 330ml, 500ml. The product should have been tested with natural and testing certificate to be provided by manufacturer, Anchors and Rebar's to use in cracked/un-cracked concrete/Rock, tested for service temperature of -40deg C to +80 deg C. Anchoring with rod/bar. LEED certified injection adhesive for rebar fixing in wet/dry flooded holes conditions for diameters. The chemical should have service life of more than 50 years and is to be tested for water tightness. Drilling hole with double flute type drill bits/hollow drill bits to the required depth by rotary hammer drill, filling resin and hardener using serrated nozzle to eliminate mixing error with standard HDE A22 battery dispenser along with piston plug and extension hose for longer depths to ensure no air bubbles are in the hole and then fixing the re-bar,

conducting occasional site inspection, executing work by trained personnel and occasional supervision from the manufacturer's representative in India. The installation and the setting instructions should be strictly followed as per the manufacturer's recommendations & as per instruction by Engineer In charge.

30. All necessary labour, materials, equipment, etc., for sampling, preparing test cubes, curing etc., shall be provided by the Contractor. Testing of the materials and concrete may be arranged by the Engineer-in-charge in an approved laboratory at the cost of the contractor.

31. **"The rate of P.C.C. shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."**

32. The payment will be made on **Cu.m.** basis of the finished work.

33. The unit rate for concrete shall include the cost of all materials, labour, tools and plan required for mixing, placing in position, vibrating, compacting finishing & rebarring of anchor bar as per drawing & as-per directions of the Engineer-in-charge, curing and all other incidental expenses for producing concrete of specified strength to complete the structure or its components as show on the drawings and according to these specifications. The rate shall also include the cost of providing and laying of Anchor bar .

Item No.10:- Providing and casting in-situ controlled cement concrete M 35 For R.C.C. pile cap including necessary form work vibrating, curing and finishing complete.

This work shall consist of providing and casting in situ-controlled cement concrete M-35 grade for **R.C.C. pile cap** and shall be carried out as per relevant detailed specification of **Item No.4** of this contract.

"The rate of R.C.C. pile cap shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

The payment will be made on **Cu.m.** basis of the finished work.

Item No.11:- Providing and casting in situ controlled cement concrete M-35 for R.C.C. return as per drawings including centering shuttering, scaffolding where necessary, laying vibrating, curing and finishing complete.(A) Height from 0.0 to 5.0 M. (1) Piers (2) Abutment (3) RCC return

This work shall consist of providing and casting in situ-controlled cement concrete M-35 grade for **R.C.C. return** and shall be carried out as per relevant detailed specification of **Item No.4** of this contract.

"The rate of R.C.C. sub structure shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

The payment will be made on **Cu.m.** basis of the finished work.

Item No.12:- Providing and casting in situ controlled cement concrete M-35 for R.C.C. return as per drawings including centering shuttering, scaffolding where necessary, laying vibrating, curing and finishing complete.(A) Height from 5.0 to 10.0 M. (1) Piers (2) Abutment (3) RCC return

This work shall consist of providing and casting in situ-controlled cement concrete **M-35 grade** for **R.C.C. return** and shall be carried out as per relevant detailed specification of **Item No.4** of this contract.

"The rate of R.C.C. sub structure shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

The payment will be made on **Cu.m.** basis of the finished work.

Item No.13:- Providing and casting in situ controlled Cement Concrete M-35 for R.C.C. works in pier cap abutment cap and dirt wall including controlled cement concrete M-40 Bed block or pedestal or required size below bearings as per detailed drawings, centering, shuttering,

scaffolding, wherever necessary, laying vibrating curing and finishing complete.

This work shall consist of providing and casting in situ- **M-35 grade** for **pier cap abutment cap and dirt wall** and **M-40 Bed block or pedestal** shall be carried out as per relevant detailed specification of **Item No.4** of this contract.

"The rate of R.C.C. pier cap, abutment cap, Bed block or pedestal shall be full compensation for providing and maintaining cofferdam and dewatering arrangements wherever required, complete in all respects. No extra item or additional payment shall be admissible for cofferdam works."

The payment will be made on **Cu.m.** basis of the finished work.

Item No.14:- Providing and casting in situ or precast controlled Cement Concrete M-45 for prestressed concrete work in Super structure including centering, shuttering, curing, scaffolding, ramming, vibrating, finishing complete.(I) Solid Slab.(II) Deck Slab.(III) Main Girders.(IV) Diaphragm or cross girder.

2305. PRESTRESSED CONCRETE CONSTRUCTION

2305.1. PSC Girder and Composite RCC Slab

PSC Girder may be precast or cast-in-situ as mentioned on the drawing or as directed by the Engineer. Girders may be post-tensioned or pre-tensioned . Where precast construction is required to be adopted, selection of casting yard and details of methodology and of equipment for shifting and launching of girders shall be included in the method statement.

In case of cast-in-situ construction, the sequence of construction including side shifting of girders, if applicable, and placing on bearings shall be in accordance with the drawings.

The PSC girder constituting the top flange, web and the bottom flange shall be concreted in a single operation without any construction joint.

The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.

The surface finish of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened. Care shall be taken for setting of bearings as indicated on the drawings.

~~2305.2. Box Girder~~

~~Box girders may be simply supported or continuous. Simply supported box girders shall have minimum construction joints as approved by the Engineer. In the case of continuous box girders the sequence of construction and location of construction joints shall strictly follow the drawings.~~

~~The box section shall be constructed with a maximum of one construction joint located in the web below the fillet between the deck slab and web. If permitted by the Engineer, one additional construction joint may be permitted and this construction joint shall be located in the web above the fillet between the soffit slab and web.~~

~~The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if permitted by the Engineer.~~

~~The surface finish of the deck slab shall be finished rough but true to lines and levels as shown on the drawings before the concrete has hardened. Care shall be taken for setting of bearings as indicated on the drawings.~~

2305.3. Cantilever Construction

Continuity of untensioned reinforcement from one segment to the next must be ensured by providing full lap length as necessary.

The design of the superstructure shall take into account the following aspects which form an integral part of the construction operations :

- a) Stability against over-turning for each statical condition through which the assembly passes, shall be checked.
- b) Stresses at each preceding segment joint with the addition of every segment or change of statical conditions shall be checked. The load of equipment as well as construction live load shall be taken into account
- c) Precambering of the superstructure during construction shall be done in such

a manner that the finally constructed structure under permanent load attains the final profile intended in the drawings.

2306. TOLERANCES

2306.1. Precast Concrete Superstructure :-

Variation in cross-sectional dimensions :

- | | | | | | |
|----|---|---|--------------------------|------|----|
| a) | upto and including 2m | : | \pm | 5 | mm |
| | over 2m | : | \pm | 5 mm | |
| b) | Variation in length overall and length between bearings | : | shall not exceed | | |
| | | | ± 10 mm or ± 0.1 | | |
| | | | per cent of the | | |
| | | | span length, which- | | |
| | | | ever is lesser | | |
| c) | Permissible surface irregularities when measured with a 3 m straight edge or template : | | 5mm | | |

2306.2. Cast-in-Situ Superstructure

- | | | | |
|----|---|---|------------------------------|
| a) | Variations in, thickness of top and bottom slab for box girders, top and bottom flange for T-girders or slabs | : | -5mm to ± 10 mm |
| b) | Variations in web thickness | : | -5mm to ± 10 mm |
| c) | Variations in overall depth or width | : | ± 5 mm |
| d) | Variation in length overall and length between bearings | : | shall not exceed |
| | | : | ± 10 mm to ± 0.1 |
| | | | per cent of the span |
| | | | length, which-ever is lesser |
| e) | Permissible surface irregularities when measured with a 3 m straight edge or template | : | 5mm |

1801. DESCRIPTION

Structural concrete containing prestressed steel reinforcement to introduce pre compression is termed as prestressed concrete.

The work shall be carried out in accordance with the drawing and specifications or as approved by the Engineer.

Concrete and untensioned steel for the construction of prestressed members shall conform to the requirements of sections 1700 & 1600 for Structural Concrete and Steel Reinforcement respectively so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

1802. MATERIALS

1802.1. All materials shall conform to Section 1000 of MORT & H specification

1802.2. Sheathing

1802.2.1. The sheathing ducts shall be of the spiral corrugated type. Unless otherwise specified, the material shall be Cold Rolled Cold Annealed (CRCA) Mild Steel conforming to IS:513 intended for mechanical treatment and surface refining but not for quench hardening or tempering.

The material shall normally be bright finished. However, where specified, as in case of use in aggressive environment, galvanised or lead-coated mild steel strips shall be used.

The thickness of sheathing shall be as shown on the drawing, but shall not be less than 0.3 mm, 0.4 mm and 0.5 mm for sheathing ducts having internal diameter of 50 mm, 75 mm and 90 mm respectively. For bigger diameter of ducts, thickness of sheathing shall be based on recommendations of prestressing system supplier or as directed by the Engineer.

The sheathing shall conform to the requirement as per tests specified in *Appendix 1800/I*.

For major projects, the sheathing ducts should preferably be manufactured at the project site utilising appropriate machines. With such an arrangement, long lengths of sheathing ducts may be used with consequent reduction in the number of joints and couplers. Where sheathing duct joints are unavoidable, such joints shall be made slurry tight by the use of corrugated threaded sleeve couplers which may be tightly screwed onto the outer side of the sheathing ducts.

The length of the coupler should not be less than 150 mm but should be increased upto 200 mm wherever practicable. The joints between the ends of the coupler and the duct shall be sealed with adhesive sealing tape to prevent penetration of cement slurry during concreting. The couplers of adjacent ducts should be staggered wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers are being conveniently manufactured using the sheath making machine with the next higher size of die set.

1802.2.2. The internal area of the sheathing duct shall be in accordance with the recommendations of the system manufacturer and shall be about three times the area of the tendons. In case of 6T13, 12T13 and 19T13 sizes of tendons comprising 12/13 mm dia strands, the inner diameter of the sheathing shall not be less than 50 mm, 75 mm and 90 mm respectively or those shown in the drawing, whichever is greater.

Where prestressing tendons are required to be threaded after concreting the diameter of sheathing shall be about 5 mm larger than that required as above.

1802.2.3. In severe environment, cables shall be threaded after concreting. In such cases a temporary tendon shall be inserted in the sheathing or the sheathing shall be stiffened by other suitable method during concreting.

1802.3. Anchorages

1802.3.1. Anchorages shall be procured from authorised manufacturers only. Anchorages shall conform to BS:4447. Test certificates from a laboratory fully equipped to carry out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

1802.3.2. Swages of prestressing strand and button-heads of prestressing wire, where provided shall develop a strength of at least 95 per cent of the specified breaking toad of the strand or wire as the case may be. Where swaging/button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to his taking up the work.

1802.3.3. Untensioned Steel reinforcements, around anchorages shall conform to the details of prestressing system and as shown on the drawing.

1803. TESTING OF PRESTRESSING STEEL AND ANCHORAGES

All materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

All wire, strand or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be like-wise identified.

All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll. The Contractor shall furnish samples of at least 5.0 m length selected from each lot for testing. . Also, two anchorage assemblies, complete with distribution plates of each size or types to be used, shall be furnished along with short, lengths of strands as required.

1804 WORKMANSHIP

1804.1. Cleaning

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance.

Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing carborundum powder. However, the tendons shall not be brought to a polished condition.

1804.2. Straightening

High tensile steel wire and strand shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight

as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used. The packing of prestressing wire/strand shall -be removed only just prior to making of cable for placement Suitable stands shall be provided to facilitate uncoiling of wires/strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

1804.3. Positioning

1804.3.1. Post-Tensioning

Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks.

The locationing of prestressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons. High capacity tendon shall be used to reduce the number of cables thereby eliminating the necessity of grouping. The selected profiles of the tendons shall be such that their anchorages are not located in the top deck surface. Where two or more rows of cables have to be used, the cables shall be vertically in line to enable easy flow of concrete. The clear vertical and horizontal distances between any two cables shall in no case be less than 100mm anywhere along the length of the superstructure. Where precast segments are used, the clear distance shall be at least 150 mm.

Sheathing shall be placed in correct position and profile by providing suitable, ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars so that they do not get disturbed during concreting.

The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.

Sheathing in which the permanent tendon will not be in place during concreting shall have a temporary tendon inserted or shall be stiffened by some other method to the approval of the Engineer. The temporary tendon shall be pulled out before

threading the permanent tendon into place by a special threading machine or other contrivance.

Where possible tendons shall not be placed until immediately prior to stressing. Tendons shall be handled with care to avoid damage or contamination, to either the tendon or the sheathing. Any tendons damaged or contaminated shall be cleaned or replaced.

1804.3.2. Pre-Tensioning. Prestressing steel shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

1804.3.3. Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.

The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete which adheres to bearing or wedging surfaces, shall be removed immediately.

1804.4. Cutting

Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel, The location of flame cutting of wire or strand shall be kept beyond 75 mm of where the tendon will be gripped by the anchorage or jacks.

In post-tensioning the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

1804.5. Protection of Prestressing Steel

Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer.

In the case of external prestressing, steel shall be encased in suitable polyethelene pipes before grouting.

1804.6. Sheathing

The joints of all sheathings shall be water-tight. Special attention shall be paid to the junction at the anchorage end, where the sheathing must tightly fit on the protruding trumpet end of anchorage and thereafter sealed preferably with heat shrink tape, to make it waterproof.

The heat-shrink tape is supplied in the form of bandage rolls which can be used for all diameters of sheathing ducts. The bandage is coated on the underside with a heat sensitive adhesive so that after heating the bandage material shrinks on the sheathing duct and ensures formation of a *leak-proof* joint. The heating is effected by means of a soft gas flame.

A sheath making machine should be positioned at the site of work for large projects so that sheathing can be prepared as and when it is required for construction.

The sheathing and all joints shall be water tight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

1804.7. Grout Vents

Grout vents of at least 20 mm diameter shall be provided at both, ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacing of consecutive vents do not exceed 20 m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0 MPa without the loss of water, air pressure or grout.

1804.8 Anchorages

All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning.

Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the anchorage assembly.

The anchorages shall be recessed from the concrete surface by a minimum cover of 100 mm.

After the prestressing operations are completed and prestressing wires/strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 microns per coat and entire recess shall be filled with concrete or non-shrink/pre-packaged mortar or epoxy concrete.

1804.9. Structural Concrete

Structural concrete shall be design mix concrete of **M45 grade** using **Portland Slag Cement** and shall be carried out in accordance with the relevant specification of It. No. 7 of this contract.

1805. SUPERVISION

All prestressing and grouting operations shall be undertaken by trained personnel only. A representative of supplier of the prestressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

1806. TENSIONING EQUIPMENT

All tensioning equipment shall be procured from authorised manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power-driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements

(i) The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.

(ii) Where two or more wires/strands constitute a tendon, a single multipull stressing jack shall be used which is capable of tensioning simultaneously all the wires/strands of the tendon. Suitable facilities for handling and attaching the multipull jack

to the tendons shall be provided.

(iii) The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete; and

(iv) Means shall be provided for direct measurement of the force by use of dynamometers or pressure gauges Tilted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the linear measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.

All dynamo meters and pressure gauges including a master gauge shall be calibrated by an approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

Pressure gauges shall be concentric scale type gauges accurate to within two per cent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 per cent of its breaking load, the gauge is reading between 50 per cent and 80 per cent of its full capacity.

Suitable safety devices shall be fitted to against sudden release of pressure.

Provision shall be made for the attachment of the master gauge to be used as a check whenever requested for by the Engineer.

1807. POST-TENSIONING

Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily so as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows:

a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.

b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5 kg/sq. c.m. until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.

c) If the elongation at 1.05 times the specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken in succession, to determine the cause of this lack of discrepancy :

- i) Check the correct functioning of the jack, pump and leads.
- ii) Detension the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Retension the cable if free.
- iii) Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory.

If the required elongation is still not obtained, further finishing operations such as cutting or sealing, should not be undertaken without the approval of the Engineer.

d) When stressing from one end only, the slip at the end remote from the

jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in *Appendix 1800/II*. The number of stages of prestressing and grouting shall be reduced to a minimum, preferably 2 in the case of simply supported girders.

1808. GROUTING OF PRESTRESSED TENDONS

Grouting shall conform to *Appendix 1800/III*. A record of grouting operations shall be maintained in the format given in *Appendix 1800/ IV*.

1809. PRE-TENSIONING

1809.1. General

The planning and construction aspects of the tensioning bed, tensioning bench, abutments at location of anchorage, steam curing system, formwork of the concrete elements and arrangements for demoulding, lifting, stacking and transportation of the pre-tensioned concrete elements are all specialised items and shall be entrusted to engineers specifically experienced in this type of work.

1809.2. Stressing Bed for Pre-tensioning

The abutments and bed for pre-tensioning of tendons shall be designed to withstand the total tensioning force.

A notice shall be displayed adjacent to the stressing bed showing the maximum tensioning force permitted.

Where concrete elements are cast and prestressed individually, the stressing bench or moulds shall be rigid enough to sustain the reaction of the prestressing force without distortion.

In the long line method of prestressing, sufficient locator plates should be distributed throughout the length of the bed to ensure that the wires are maintained in their proper position during concreting; The moulds shall be free to slide in the direction of their length and thus permit the transfer of the prestressing force to all the concrete elements along the whole line.

Sufficient space shall be left in between the ends of concrete elements to permit access for cutting the strands/wires after transfer. Hold-downs or deflectors shall be used for holding or deflecting the tendons in required position firmly. Deflectors which are in contact with the tendon shall have a diameter not less than the tendon or 15 mm, whichever is greater.

The tensioning force required to be applied as stated on the drawings shall be the force remaining in the strands/wires after all strands/wires' have been anchored to the abutments of the stressing bed and after the anchorage slip has already taken place. The tensioning force shall be determined by direct reading of the pressure gauges or dynamo-meters and by the measured elongation after slip.

The Contractor shall submit method of tensioning the tendons including the arrangement and layout of prestressing beds and all tendon deflection points to the Engineer for approval before manufacture commences.

The Contractor shall carry out trial stressing operations to establish the frictional resistance offered by the hold-downs and the slip during anchoring.

Where sheathing of pre tensioned tendons is required to prevent bond over a specified length, it shall consist of plastic tubing or other material approved by the Engineer and shall be of a quality, diameter and thickness such that bond shall be effectively prevented. The tubing shall be fastened to the tendon in such a manner that cement mortar cannot enter. The Engineer may order that the pull-in of the tendon be measured during the transfer of prestress.

The Contractor shall also submit calculations showing that the hold-downs have been designed and constructed to withstand concentrated loads resulting from the application of the tensioning force.

1809.3. Tensioning Procedure

The tensioning of the wires and strands shall be done not too much in advance of concreting.

The tensioning force shall be applied gradually and uniformly.

In order to remove slack and to lift tendons off the bed floor, an initial force approved by the Engineer shall be applied to the tendons. Allowance shall be made for this force in calculating the required elongation.

Tendons shall be marked for measurement of elongation after the initial force has been applied. When required by the Engineer, tendons shall be marked at both the jacking end and dead end of the stressing bed and at couplers if used so that slip and draw-in may be measured.

Where deflected strands have been specified, the Engineer may direct the elongation or strain gauge measurements be taken at various positions along the tendon to determine the force in the tendon at those positions.

1809.4. Transfer of Prestress

While the process of tensioning can be accomplished by means of hydraulic jacks, some positive mechanical means shall be provided to maintain the tension during the entire period between the tensioning of the wires/strands and transfer of the prestressing force to the concrete element.

Transfer of prestress shall not proceed until the Engineer has approved the proposed method. Tendons and deflection devices shall be released in such a pre-determined order that unacceptable tensile stresses are not induced in the concrete.

Prior to transfer of the force to the units, all tendons shall be tested for tightness and any loose tendon shall be reported to the Engineer who will decide whether the units affected shall be rejected.

The Engineer may require that tendons be marked at each end of any unit to allow measurement of the pull-in of the concrete.

Tendons shall be released gradually and preferably simultaneously. Under no circumstances shall tendons be cut while under tension.

On completion of the transfer of prestress, the projecting lengths of tendon shall be cut off flush with the end surface of the unit, unless otherwise shown, by a method approved by the Engineer.

In no case shall the transfer of prestressing force to the concrete elements take place before concrete attains the strength specified in the drawings. To determine the specified strength, additional cube testing shall be undertaken at the Contractor's cost. In case steam curing is employed, the cubes shall be placed in the same environment as the concrete elements to obtain an accurate assessment of concrete strength at the time of transfer.

The sequence of transfer of prestressing force shall be done strictly as indicated in the drawings and ensuring that eccentricities of the prestressing force in the vertical and horizontal directions of the concrete element is a minimum during the entire sequence.

The maximum slip of any tendon during transfer shall not exceed 3 mm at any end of the concrete element. In case this slip is exceeded, the concrete element in question shall be rejected.

1809.5. Protection of Ends

The exposed ends of the tendons and the concrete surfaces of the ends of the units shall be wire brushed clean of all rust, loose mortar, grease and dirt.

The exposed ends of the tendons and concrete surface within 50 mm' of tendons shall be then abraded to provide a clean sound surface. An epoxy tar paint suitably formulated to give a dry film thickness of 80 microns per coat shall then be immediately applied over the ends of the tendons unless otherwise directed.

A second coat of paint shall be applied prior to the drying out of the first coat.

1810. SAFETY PRECAUTIONS DURING TENSIONING

Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

The operations of the jacks and the measurement of the elongation and associated operations shall be carried out in such a manner and from such a position that the safety of all concerned is ensured.

A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

During actual tensioning operation, warning sign shall be displayed at both ends of the tendon.

After prestressing, concrete shall neither be drilled nor any portion cut nor chipped-away nor disturbed, without express approval of the Engineer.

No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon which has been affected by welding, weld spatter or heat shall be rejected.

1811. TRANSPORTATION AND STORAGE OF UNITS

Precast girders shall be transported in an upright position. Points of support and the direction of reactions with respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being damaged. Units damaged by improper storing or handling shall be replaced by the Contractor at his expense

The girders may be precast in a yard and launched into position using any approved method of launching with prior approval of the Engineer-in-charge satisfying all the requirements and supporting their proposals for launching with detailed design and drawings. All materials and equipment required for launching shall have to be designed and got approved from the Engineer-in-charge. The launching shall be the responsibility of the contractor and the approval by the Engineer-in-charge to the

design and drawing of the launching system shall in no way relieve the contractor of the responsibility for its successful working. The contractor is expected to take all necessary precautions. The contractor shall be responsible for any damage or loss in the process of launching, side-shifting and any other operation, and the same shall be made good by him at his own cost. Sheaths shall be placed and aligned strictly as shown on the drawings and maintained securely to prevent displacement during placing the compaction of concrete.

1812. TOLERANCES

Permissible tolerances for positional deviation of Prestressing tendons shall be limited to the following

- a) Variation from the specified horizontal profile : 5 mm
- b) Variation from the specified vertical profile : 5 mm
- c) Variation from the specified position in member : 5 mm

1813. TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

1814. MEASUREMENTS FOR PAYMENT

Prestressed Concrete shall be measured in **Cu.m.** The volume occupied by mild steel reinforcement/HYSD bars, high tensile steel, sheathing and anchorages shall not be deducted.

1815. RATE

The contract unit rate for cast-in-place prestressed concrete shall cover the cost of all materials, labour, tools and plant required for mixing, placing in position, vibrating and compacting, finishing as per directions of the Engineer, curing and other incidental expenses for producing concrete of specified strength to complete the structure or its components as shown on the drawings and according to specifications. The contract

unit rate shall also include the cost of making, fixing and removing of all centring and forms required for the work unless otherwise specified in the Contract.

For precast prestressed concrete members, the rate in addition to above shall also include the cost of all materials, labour, tools and plant required to transport and place these members in their final position as shown on the drawings and as directed by the Engineer

Item No.15:- Launching of Precast PSC I Girders using suitable capacity of cranes/truss including transportation, loading & Unloading etc. complete as per sepecification.

1. INTRODUCTION:

A Launching Girder also called as Launching Gantry, Beam Launcher, Girder Launcher, Bridge Building Crane and Bridge-Building Machine. In this manual it has been collectively mentioned as Launching Girder (LG).

Launching of Girders basically involves various operations like preliminary design, casting, stacking, assembling, handling in between casting yard and bridge proper, putting the assembled girders in position over pier caps and lowering of girders to their final position over bearings.

Launching Girders (LG) and Spreader Beams (SB) are developed and used for placing precast bridge viaducts. They are to be specially designed for use in restrictive construction environment to overcome limited access from ground.

Launching Girder design is consists of lifting devices with mechanical, electrical and/or hydraulic components, and a supporting structure. Due to its sophisticated nature, it is necessary to develop detailed procedures, and limit their strict implementation by experienced operators and workers to ensure safety of the personnel working at or nearby the machines and the public.

A launching girder is a special-purpose mobile gantry crane used in bridge construction. The launching Gantry is used to lift and temporarily support the

bridge girders as they are placed in their final position. The launching gantry is supported by the bridge piers instead of the ground.

While launching gantry should not be confused with movable scaffolding systems, which also are used in Girder bridge construction. Both feature long girders spanning multiple bridge spans which move with the work but launching gantry machines are used to lift and support precast bridge girders, while movable scaffolding systems are used for cast-in-place construction of bridge girders.

Typically, precast girders are placed using ground-based cranes to lift girder. However, ground access to the spans may be challenged by the presence of existing infrastructure or bodies of water, or the height to which the Girder must be raised can exceed the reach of ground-based cranes. A launching gantry can be used to solve these issues.

The most visible feature of a launching gantry are the twin parallel girders, which can either be above (upper-beam) or below (lower-beam or underslung) the bridge deck. However, a single beam can also be used, typically in upper- beam configuration. The launching gantry usually is sized to the construction project, with the length of the twin main girders approximately 2.3 times the distance between spans. This length enables the launching gantry to span the gap between two adjacent bridge piers while providing allowances for the distance required for launching to the next span and flexibility of movement to accommodate curved paths between piers. In some cases, hinges have been inserted into the gantry girders to allow tighter curves. The launching gantry girders are supported at each pier by braced frames which have a limited range of movement to facilitate placement of bridge girders; the launching gantry does not generally contact the bridge deck.

Two gantry trolleys can run the full length of the launching gantry girders. Each trolley is equipped with two winches: a main winch to suspend the load,

and a translation winch to move the trolley along the girders. If the girders are delivered instead at the bridge deck level, the launching gantry moves back to allow the forward trolley to pick up the front end of the next girder, while the back end of the girder is supported by the transportation vehicle; as the forward trolley moves forward, the rear trolley takes over supporting the back end from the vehicle.

Bridge girders are set in place by the launching gantry until the span between adjacent piers is completed. To free up the gantry trolley(s), temporary hangers are used to support each Girders after it has been placed. In the span-by-span approach, all the Girders for a span are placed before bridge tendons are tensioned; in this fashion, work progresses from one pier towards an adjacent pier. In the balanced- cantilever approach, Girders are placed simultaneously on each side and work progresses from a central pier towards the two nearest piers instead. In either case, the launching gantry girders and hangers essentially serve as falsework prior to tensioning.

Once the bridge span between adjacent piers is completed, the winches on the trolleys are used to lift the gantry girders and "launch" them ahead to the next span. The process of lifting and placing bridge girders followed by launching the gantry girders ahead is repeated until the bridge is complete.

2. SCOPE:

Erection of bridge super-structure in pre-cast construction is one of the important and critical activities. There are many methods available for bridge super-structure erection as per site conditions and type of bridge design. Use of Launching Girder for bridge super-structure erection is one of such methods. These guidelines gives in depth methodology and procedures to be adopted in design, erection & operation of Launching Girder.

3. DEFINITIONS:

For the purposes of the guidelines, the following terms and definitions apply:

Casting Bed: A special formwork arrangement usually consisting of a fixed vertical bulkhead of the cross-section shape at one end and adjustable soffit, side and core forms all designed and assembled into a machine for making a single superstructure. It shall have proper foundation to have settlement free soffit profile throughout the pre-casting period.

Wet Joint System: Where girders are made in a casting bed between two bulkheads and are not match cast. The girders are then erected in the superstructure. During erection, all the span or multiple spans are supported by Launching Girder, truss or other technique until the joints have gained strength and the longitudinal post-tensioning installed to make them self-supporting.

Span By Span (Erection): Placing a specified number of Girders on a temporary support system/Launching Girder, aligned and post-tensioned longitudinally forming a completed span of the superstructure.

Progressive Cantilever/Incremental Launching Method (Erection): The girders are erected progressively in cantilever, in one direction, from one pier to the next, using temporary intermediate piers, or other systems as required to support the advancing cantilever between piers.

Full Span Method (Erection)

The Full Span Method (FSM) involves casting the whole bridge span in the casting yard and transporting the whole span with a specially designed multi axle tyre trolley to the bridge site. At the bridge site a specially built Full Span Method launching system will be used to lift and place the whole span in the final position.

Advance Shoring / Movable Scaffolding System (MSS)

The Advance Shoring / Movable Scaffolding System (MSS) method involves moving of launching girder on the bridge piers, span by span to allow placing of the cast in Situ concrete. This is applicable for both underpinning and overhead systems.

Casting Curve: The curve of casting geometry that has to be followed in the casting bed for achieving the theoretical bridge profile and alignment after all the final structural and time dependent (creep and shrinkage) deformations have taken place. The casting curve is a combination of the theoretical bridge geometrical profile grade, alignment and the camber.

Pre-Camber: The amount by which the concrete profile at casting time must differ from the theoretical geometric profile grade to compensate for all structural dead load, post-tensioning, all long term and time dependent deformations (creep and shrinkage) including all the intermediate erection stages and effects. (The opposite of deflections).

Erection Elevation: The elevation at which a Girders is set in the structure at the time it is erected. This is profile grade corrected by the amount of deflection calculated to occur from that stage onwards.

Launching Girder (LG)

Launching Girders (LG) are basically structural members strong in flexural strength most commonly used for placing pre-cast post-tensioned concrete PSC Girders to form viaducts and bridges. Other unique ability of Launching Girders is to move themselves forward to the next span/position hence they are particularly economic for multi-span structures.

Spreader Beam (SB)

A Spreader Beam (SB) is a long member that holds one or two slings apart on upper part, distributing the weight of a load evenly over two or more attachment points on lower part. In such arrangement of load lifting, the lifted load predominately puts Spreader Beam in compressive stress in between two lifting points.

Lifter Beam (LB)

A Lifter Beam (LB) has central attachment points on the upper side of the beam for attaching to a crane or other lifting apparatus and supports a load via two or more connection points on the lower side of the beam. In such arrangement of load lifting, the lifted load predominately puts the Lifting Beam in bending stress.

Lifter Frame (LF)

A lifting frame is in general a design-and-built machine used in Girder bridge construction. It consists of lifting devices and metal structures for lifting bridge Girder in position for assembling. Some LFs are mobile machines moving forward or backward on the connected bridge deck, and anchored to the bridge deck when reaching its working position. A lifting frame usually consists of two main cantilever beams fixed to the main structure and a lifting device that could move horizontally along the cantilever beams while suspending/lifting bridge Girder for assembling. The suspended bridge Girders may be moved horizontally or vertically by the machine during assembling.

4. DESIGN STAGES

PRELIMINARY DESIGN AND PLANNING CONSIDERATIONS

- Identification of Critical Restrictions:

Early recognition of project site challenges such as environmental issues or sites which offer only limited access for construction make it easier to consider the value of alternative construction methods as early in the preliminary design phase as possible.

- Establishment Advisory Panel

The value of an advisory panel for any specialized project that has not been attempted by a particular owner cannot be overemphasized. Owners, designers and contractors are available who are willing to share their experiences (positive and negative) and assist the owner by providing examples of previous projects. The establishment of a contractor advisory panel should be considered well in advance of the project letting date and preferably early in the design phase of the project. The members of this panel should include experienced bridge contractors of moderate to large size from the surrounding area and, depending on the size and location of the project.

- Finalization of Specialty Equipment Manufacturers

Manufacturers of specialty bearings, rollers and jacking equipment should be contacted to obtain examples of innovative solutions which have been used for similar projects. The use of Launching Girder in particular is one method which has seen relatively widespread use in India and around the world which has spurred the development of specialized equipment.

- Limitations of Launching girders.

Limitations of Launching girder like curvature radius, maximum span longitudinal as well as transverse gradient, launching girder moving speed etc. shall be taken into account while designing and planning the Launching Girders.

FINAL DESIGN PHASE CONSIDERATIONS

- Substructure Effects Caused by Launching Forces

The forces applied to a substructure element due to launching a bridge include three vector components which include the following:

- Vertical loads due to representing the dead load support reaction at the pier.
- Longitudinal loads generated by the friction and other resistance forces in the bearings as well as the local grade (if any) of the launch surface.

- Transverse horizontal component generated by the lateral guide system
 - Wind Forces during Launching

It is highly recommended to consider the effects of wind on a potential Launched Girder. The effect of both static and dynamic wind forces during the construction of the bridge using incremental launching must be considered, particularly in the case of a lighter-weight superstructure like metro viaducts. In order to eliminate potential problems with wind effects during a launching operation, it is recommended to have auto launching and other critical launching activities only when the wind speed is 15Kmph or less. The recent availability of internet-based weather documentation and prediction forecast sites make it routine practice to verify the predicted wind speeds for 12 hour periods in advance of a critical event.

- Reversible Launching System

In order to reduce the chance that a bridge Girder is left in a vulnerable position with a heavy weight and shape for an extended period of time, the utilization of a launching system that is reversible is recommended. In other words, make it possible to retract the Girders/Girder back to a suitably stable position in the event of a mechanical problem. It would also be wise to ensure that each launch event be suspended at a stable position with only a minimum loaded component.

- Lateral Bracing System for Launching Girders

The modern concept of Launching Girder was developed primarily for erection of concrete box girder/I Girder superstructures. These Launching Girders are inherently very stiff and provide considerable resistance against torsional buckling during the launching phase. However, this same resistance is not pertinent for a Launching Girder during Auto-Launching. A system of upper-and-lower lateral bracing is highly recommended to be included in the design of steel Launching Girders in order to provide the necessary torsional stiffness during Auto- Launching operations. This bracing should be designed as a

primary member for calculated loads during the cantilever stage. In particular, the bracing is of critical importance in the front end of launching Girder, which undergoes reverse bending during the cantilever stage of Auto-Launching.

- Temporary Supports and Auxiliary Piers

The need for temporary piers constructed at midspan of the permanent crossing can rarely be justified except in the case of extremely long spans. The aim of the design team would be to reduce the free cantilever length as much as possible. In such situations due to long cantilever span during Auto-Launching the reaction on end support may be significant. This reaction shall be considered on permanent piers/auxiliary pier (if any). A suitable temporary support in the form of steel stool or pedestal of adjustable height shall be designed for this purpose.

- Girder Stresses and Wheel Loads during Launching.

It should be noted that large contact stresses must be considered during design and appropriate consideration must be given to both localized effects on the cantilever projection of pre-cast Girders. Due to lifting of Girders with lifting points on cantilever portion the structural behavior of cantilever slab may reverse. The same shall be addressed during design itself.

When rolling the Launching Girder over deck slab a series of roller supports transfer the reaction to the deck slab, essentially in the form of point. It may be critical load on box girder deck slab and shall be designed appropriately to resist this loading without the risk of local cracking or failure due to the combined flexure/shear acting at this point.

IN NO CASES STRESSES SHALL BE EXCEEDED THAN PERMISSIBLE STRESSES IN TEMPORARY STRUCTURES LIKE LAUNCHING GIRDERS.

- Required Jacking Forces to Overcome Friction and Longitudinal

Grade The use of a low friction roller system is recommended for use on all

Launching Girders. These rollers are typically assumed to provide a frictional resistance of 5 percent when rolling across a surface of rails or steel surface. As far as possible the rolling surface shall be kept horizontal. However, launching on grade shall be done with additional arrangement to arrest the back rolling due to gravity.

- Analysis of Erection Stages

During launching different components of Launching Girder as well as Bridge super-structure are subjected to various types of stresses and of various magnitudes. This phenomenon necessitates to check these stresses at different stages of erection/launching. Accordingly, the provisions shall be made in Launching Girders as well as in permanent structure design to match these loading conditions. Each critical erection stage shall be analyzed and the permanent structure shall be checked against strength and stability as a whole.

a twin-upper-beam gantry with support cross beams.



Long twin-upper-beam gantry is used for balanced-cantilever erection



5. DESIGN METHODOLOGY & CRITERIA PLANNING AND OPERATIONS

• Casting Yard Planning

Basic requirements of pre-casting activity shall be planned in casting yard. Various activities like bar bending, casting, stacking and handling of pre-cast elements, storing & sorting of raw materials shall be properly studied before finalizing the layout. Methods for Girders casting including layout of the casting yard, set up and operation of the casting cells, movable rain and sun shades, geometry control stations, the storage and handling of rebar cages, the preparation of as built geometry data, placing and finishing concrete, curing of concrete, form stripping, bond breaking, and other similar items shall be planned efficiently.

Equipment for Girders casting, including details of the forms and casting cells for the manufacture of the Girders, surveying the Girders, lifting and transportation of the Girders in the yard and other similar items.

Following are the key points regarding establishment of a well-planned casting yard:

- A schedule of materials for Girder casting including concrete, reinforcing steel, prestressing steel, duct filler, and other similar items.
- Each Girders number and the direction of erection.

- girder dimensions including widths, lengths, thicknesses, tapers, fillets, radii, working points, post-tensioning, clearances, rebar dimensions and spacing, embedded items, holes, anchorage positions, and other similar items.
- Post-tensioning requirements: Check post-tensioning for consistency with pre- approved post-tensioning hardware and provide part numbers for department pre-approved systems on the shop drawings.
- The volume of concrete, weight of reinforcement and weight of post-tensioning in each precast Girders and the total weight for reinforcement and post-tensioning for the superstructure shall be summarized and tabulated on the shop drawings.
- Details and calculations for any localized strengthening for concentrated supports and loads or reactions from any special erection equipment placed in locations not already allowed for in the Plans.
- Details and supporting calculations for any modifications to Girders geometry, cross section dimensions, or Girders length including any required changes to reinforcing and post-tensioning.
 - Details of permanent and temporary embedded items including inserts, blackouts, temporary openings, holes, and other similar items; and any localized required strengthening and the materials and methods to fill and finish the holes.

Casting of girder shall not be started until the Engineer approves the relevant shop drawings, calculations, casting manuals, concrete forms and concreting operations and the post-tensioning system components and layout Plans. Approval of post-tensioning stressing elongations and forces for field erection operations is not required at this stage but is required prior to erection. On each Girders an erection mark indicating its location, orientation and order in the erection sequence shall be marked. Match mark abutting edges of adjacent Girders. Show erection marks on the erection plans or in the erection manual.

- **Stacking yard Planning**

Girders storage including layout of the storage area, method of supporting the Girders, single or double stacking, placing erection marks and Girders identification, and other similar items.

Calculations and details for lifting, storage and stacking of Girders. Additional strengthening of the Girders to accommodate stacking shall be done

at casting yard or arrangements shall be made to safe transfer of load to the base with affecting the behavior of Girders geometry.

Girders shall be handled with care to prevent damage. Girders shall be handled using only the devices shown on the shop drawings for this purpose. Stacking shall be in level in the upright position. Girders stacking and shipment shall be on approved three point bearing system which does not introduce a twist under self-weight. Stack superstructure Girders one upon another shall not be done unless approved by the Engineer. Provide a storage area of suitable stability for the Girders to prevent differential settlement of the Girders supports during the entire period of storage.

- **Transportation of Girders**

Prior to shipment the Engineer shall thoroughly inspect each Girders for damage. Thoroughly cleaning of the faces of all joints of laitance, bond breaking compound and any other foreign material by light sand blasting prior to shipment shall be done.

Make no repairs of minor spalls or chipped areas on the joint surfaces until after erection of the Girders. Upon arrival at the bridge site the Engineer will inspect each Girders again. If in the Engineer's opinion, any damage has occurred during shipment that will impair the function of the Girders (structurally, aesthetically, etc.), the Girders will be rejected.

Provide firm support at bearing locations noted above. Fully secure the Girders against shifting during transport.

- **Erection of Launching Girder**

The erection of Launching Girder shall be done on firm ground within the first span or behind the abutment. The SBC of foundation strata shall be confirmed with design value. Separate design analysis for LG erection case shall be done based on exact methodology to be adopted. It may not be possible to

assemble entire length of the Launching Girder at the beginning where overall stability is ensured in part portion.

- **Auto-Launching over first span**

If the erection of Launching Girder is done behind abutment after erection it is to be shifted to first span by auto-launching. At this point it may not be of total length. Care shall be taken while auto-launching.

- **Launching of Girders**

Before commencing erection operations, proposals for all Girders erection operations shall be submitted in the form of manual to the Engineer for approval. This submittal must be in the form of an "Erection Manual" and include but not necessarily be limited to:

- A detailed step-by-step sequence for the erection of each Girders including all intermediate procedures relating to erection equipment, temporary and permanent post-tensioning and making of closures between spans and/or cantilevers and other required sequencing.
- Positioning, use and sequencing of falsework, jacking and/or releasing of falsework, temporary towers, supports, tie-downs, counterweights, closure devices and the like.
- Positioning, use and sequencing of erection equipment such as cranes, beam and winch devices, gantries, trusses and the like, both on and off the structure, including the movement, introduction and/or removal of any supports onto or connections with the structure. Include drawings and calculations for the structural effects of erection equipment on the structure.
- Detailed scheduling of all temporary and permanent post-tensioning operations and sequences in accordance with the Girders erection and closure operations and other required scheduling.
- Stressing forces and elongations for post-tensioning.

- A method for the field survey control for establishing and checking the erected geometry (elevations and alignments) with particular attention to the setting of critical Girders such as, for example, pier Girders for balanced cantilever erection. This information may be included in the Erection Manual or may be submitted later as a supplementary or separate document.
- Any other relevant operations as required and applicable to the structure type and construction method. Do not start erection without the Engineer's approval of the erection manual.

• **Alignment of Girders**

Numerical or graphical methods may be used for alignment control and checking during erection. Establish the key stages for checking of the erection in the erection manual and obtain the Engineer's review and approval. Key stages would include, for example, setting a pier Girders during cantilever erection and various intermediate points during subsequent Girders erection, at span closure and upon completion.

Prepare a table of elevations and alignments required at each key stage of erection in accordance with the Plans, as cast geometry, camber and erection elevations for establishing erection controls and submit to the Engineer for approval. Carefully check elevations and alignments at each stage of erection and correct as required to avoid any possible accumulation of errors. If geometric corrective measures are necessary, the Engineer will require the Specialty Engineer to develop the means and methods to ensure the epoxy joint remains watertight and free from localized stress concentrations.

• **Gluing and temporary pre-stressing**

Two-component epoxy bonding system is used between precast bridge Girders to fill voids on the faces, keep water and contaminants from seeping

into joints, prevent grout from bleeding into joints from post-tensioning ducts, and act as a lubricant between the Girders during assembly.

Properly mixed two-component epoxy bonding agent shall be applied to the match cast faces of joints between precast concrete superstructure in accordance with the approved product specifications. In its workable state, or open time, the epoxy bonding agent must function as a lubricant for joining the Girders. In its hardened state, the epoxy bonding agent must provide a watertight seal between the precast concrete Girders. The hardened epoxy bonding agent must provide intimate contact for stress transfer by completely filling all interstitial space between the match cast Girders faces.

Use only epoxy systems that are approved by the concerned department. Manufacturers seeking evaluation of their products shall submit an application conforming to the requirements of epoxy system.

For mixing, handling and applying the epoxy bonding agent, direct supervision by a person with knowledge and experience, or trained by a technical representative of the manufacturer shall be provided. It shall be ensured that all personnel who will be working with the epoxy bonding agent are thoroughly familiar with the safety precautions necessary for use of this material.

Epoxy bonding agents which remain workable for a short open time (about one hour) are referred to herein as "normal set epoxy". Epoxy bonding agents which remain workable over an extended open time (about eight hours) are referred to herein as "slow set epoxy".

Ensure that the application surfaces are free from oil, form release agent, laitance or any other deleterious material that would prevent the epoxy bonding agent from bonding to the concrete surface. Remove laitance by light sandblasting, wire brushing. Surface shape and profile of the mating surfaces shall not be destroyed. Ensure that the surfaces have no free moisture on them at the time the epoxy bonding agent is applied.

6. TYPE OF LAUNCHING GIRDERS

Bases on the type of super-structure, the Launching Girders shall be of following types:

- Launching Girders for PSC I Girders.

Based on type of structural configuration, Launching Girders shall be of following types:

- Single Box Girder type.
- Double truss type.
- Honey Comb Girder

Based on the method of erection of super-structure, launching girder/gantry shall be of following types:

- Under Slung Launching Gantry
- Overhead Launching Gantry

Launching gantries are often distinguished by the design of the main girders.

Honeycomb girder:



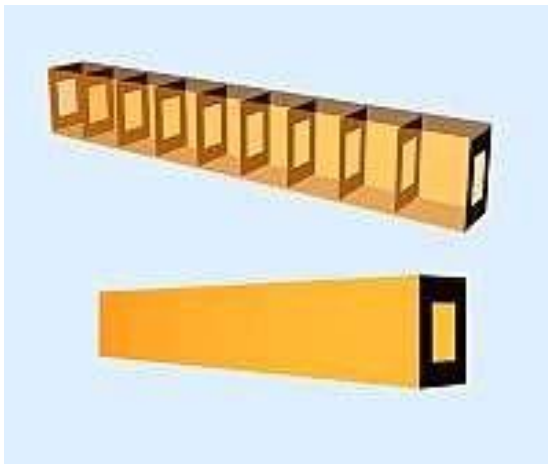
The honeycomb girder launching gantry has proven suitable to a lifting range of 5 to 300T. The main girder of a honeycomb girder is fabricated from welded plates, forming an isosceles triangle cross-section. Regular hexagonal holes are cut in the inclined web plates to reduce wind resistance. Because the honeycomb girder is formed by relatively long seam welds joining plates, the welds will not lose integrity easily due to small welding defects.

Truss girder:



The main girder of a truss girder is fabricated from welded steel poles. The welds in a truss girder are point-to-point (joining steel poles to other poles), which requires more stringent welding technology and technique. With small self-weight and large deflection, the truss girder launching gantry is suitable for highway bridge construction projects.

Box girder:



The main girder of a box girder also is fabricated from welded plates. This type of girder is usually used in high-speed railway bridge construction project.

7. SAFETY MEASURES IN LAUNCHING

Launching Girders: A Checklist for Risk

Engineers Aim and Scope:

This checklist is primarily intended to provide Risk Engineers with a simple reference tool to promote enquiries into the training, operational

practices, safety and equipment associated with the use of launching girders (LGs) for viaduct and bridge construction.

It is an effective launching system and will only be economically viable for a relatively long stretch ($> 1.5\text{km}$) of viaduct construction due to the rather high capital investment of the launching girder. Generally, the radius of curvature of the viaduct alignment must also not be too small ($>200\text{m}$).

Girders to be launched are delivered to the launching girder either from the rear or from beneath the erected spans. They are then lifted up and placed in the final positions using hydraulic jacks or winches.

Considerations must be made for the availability of a huge space to assemble and erect the launching girder, and to dismantle it upon project completion, which could be a problem if carried out in urbanized areas and heavily congested roads.

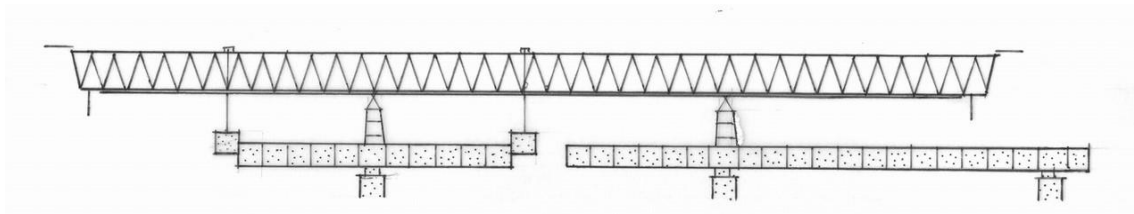
Description and Sequence:

Launching girders are relatively large pieces of equipment, their size being based on the maximum spans and Girders weights to be erected. A large Launching girder might typically weigh in excess of 800T and be in the order of 150 to 180m. in length (as a rule of thumb just over twice the length of the main spans unless intermediate temporary support systems are to be used). Regular inspection maintenance of this equipment to an approved schedule is fundamental to ensure trouble-free and safe operation. Once the Launching girders is in place the basic steps for a typical span construction are as under:

- Delivery of a Girders to the Launching girders (at deck level or from ground level)
- Pick-up and winching of Girders into its approximate position
- Application of epoxy resin to Girders faces to be joined
- Final positioning and temporary stressing for self-support (allowing

the Girders to be released from Launching girders)

- Internal permanent post-tensioning sufficient to allow placing of the next Girders
 - Repetition for further Girders until completion of the cantilevers Form and stress a concrete stitch at mid-span to complete the span
 - Launch the launching girders to next span
 - Final post-tensioning possibly continuous through more than one span
- Launching the girder to the next span is usually a multi-stage process involving tie downs, counterbalancing with pre-cast Girders and winches and the use of temporary support legs but the precise procedure to be followed will vary from one piece of equipment to another and must be clearly set out in method statements, and preferably certified by an independent checking engineer.



Launching girder in balanced cantilever mode

Insurance Aspects:

For insurance purposes launching girders may be considered either as contractor's plant or temporary works and this can be an important factor when preparing the policy documents. However, whether treated as plant or temporary works, a failure can have very serious insurance implications including: -

- Injury or loss of life by operatives and members of the public
- Third party property damage
- Damage and delay to the contract works
- Clearance of debris

Claims can arise, and have arisen, either as a result of procedures not being strictly followed or due to failure of the equipment itself and hence the development of detailed procedural steps and their very strict implementation using experienced operatives is essential to reduce the risks to their lowest achievable level.

Training and Access:

Operating and moving launching girders is a specialized process requiring staff with extensive training and experience. Whilst main contractors might wish to allocate some staff to the erection process, they should be under the direct command of a specialist from the manufacturer or a company specializing in this type of work. In addition to the task of lifting and placing the Girder these workers need to receive training in several related operations including gluing and post-stressing of the Girder together with the numerous safety requirements for standard construction such as ventilation requirements, working at height, PPE and communications. All trained staff (including resident site staff) who are permitted to access the launching girders working areas, should be clearly identifiable (usually by means of a "truss permit label" on their helmets) without which access to the fenced-off working areas above and below should be denied. In the case of shift-working a period of supervision hand-over is important to ensure on-going operations follow the correct sequence and the agreed procedures.

Detailing the Erection Procedures: Method statements, including risk assessments, should set out the procedural steps to be followed in detail and it is considered important for the manufacturer or specialist company to be directly involved in this process. Setting out the multi-stage operations is best undertaken by means of a general method statement which can then be developed into a more detailed and specific MS. These statements will invariably require diagrammatic as well as descriptive elements covering the erection sequence for each span and highlighting the particular stressing required at different times, as certified by the independent checking engineer.

The Checklist: The check-list is intended to cover most circumstances and it fully recognizes that, in most cases, Risk Engineers are unlikely to have the level of experience and knowledge approaching that of the specialist operatives. Despite this it is important that they are able to arrive at some judgement as to the overall safety of the operation and the level of risk involved. Although it might be unrealistic to expect an unqualified affirmative response to each and every enquiry on the checklist it is considered that the responses, backed up by further discussions, if necessary, should provide insurers with a good overall insight to the level of risk entailed from which proposals for safer operation might well be recommended.

The following questions are compiled for Risk Engineers making enquiries on the usage of launching girders construction. If responses are not in the affirmative it is suggested that further detailed enquiries are made, leading, if deemed necessary, to recommendations in the Risk Engineer's report.

Part 1. Working Methodology

		YES	NO
1.	Are there restrictions for off-loading Girders, for instance on seawalls, and if so, are they being complied with?		
2.	Have land transportation arrangements for Girders been developed and approved?		
3.	Are the interim storage arrangements for Girders satisfactory?		
4.	Has a General Method Statement been approved which includes items 1-3 and the general method of employing the launching girders?		
5.	Has a Specific Method Statement covering safe use of launching girder for placing Girders and moving the LG been approved? Does the MS include Risk Assessments?		
6.	Does the specific MS clearly cover in precise details? <ul style="list-style-type: none"> launching sequence for moving the LG from span to span? lifting and placing Girders on main-spans and end- spans? (iii) related tasks (e.g. temporary and permanent stressing, use of epoxy resin – see question 14.) both in 		

	words and diagrammatically?		
7.	Is the history and usage of the LG known? If so can assurance be provided that any structural modifications or any previous adverse incidents have not increased the risk of failure?		
13.	Is the commander always in radio communication with other LG operatives?		
14.	In addition to the training for operating the LG are the operatives fully trained in other relevant aspects (such as confined working space, PPE, post-stressing, working with epoxy resins, working at height, evacuation and other emergencies)?		
15.	Is access to the high-level LG working area denied to other workers? Are LG workers clearly identified (e.g. by way of permits on helmets)		
16.	Are ground-level working areas fenced off for all but essential workers? Are safety nets deployed beneath working areas?		

17.	Are rain storm/high wind/typhoon/cyclone conditions fully covered in MS with wind-speeds specified for when to deploy tie-down anchorages?		
18.	Are all lock-down and stabilizing procedures covered and complied with during off-work periods?		
19.	Is the LG required to work at gradients, e.g. for slip roads, and if so, was it designed for the gradient intended?		
20.	For lengthy girders or those in very exposed positions, does the LG have anemometers attached at both ends? And adequate lighting?		
21.	Is a lightning earthing system in place throughout the whole period on-site?		
22.	Does the site receive automatic weather updates or warnings?		
23.	Are local statutory testing requirements known for this type of equipment? Is a regular service, testing and maintenance schedule fully developed and complied with, including the keeping of records?		

Part 2. List of LG Equipment

	<ul style="list-style-type: none"> Numerous operating and safety facilities are available on modern LGs. Checking against the following list should give some further insight to the safe operating potential of the equipment. Anemometers Inclinometers Lightning conductors Adequate lighting system Inverter control system to prevent overload of capstan Central control panel Emergency stop buttons Control system to prevent overload of capstan Electrical and/or mechanical limit switches (to prevent mechanical impact) Load cells to monitor loading conditions
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- Winch safety braking
- Over-speed detection system
- Hydraulic pressure switches and valves in winch circuits and motors (to control lifting pressures and oil pressures in circuits)



Long twin-upper-beam gantry is used for balanced-cantilever erection

GUIDELINES ON SAFE USE OF LIFTING FRAMES AND LAUNCHING GIRDERS FOR BRIDGE CONSTRUCTION:

Lifting frames (LF) and Launching Girders (LG) are developed and used for placing precast post-tensioned concrete bridge Girders to form viaducts and bridges. They are specially designed for use in restrictive construction environment to overcome limited access from ground.

Safe methodology, General requirements:

At construction stage, a safe methodology shall be established and implemented for use of launching girder, which shall cover every operation cycle including the lifting operation as well as the erection/re-erection, dismantling and re-location operations. The safe methodology shall be formulated and endorsed by the Engineer-In-Charge with the input from relevant competent persons, engineering and safety professionals and/or other relevant personnel including the launching girder designer/manufacture, independent checking engineers involved in the launching girder operation. The safe methodology of work should be documented and effectively communicated to all parties concerned by the Engineer-In-Charge. The safe methodology for the launching girder should include, but not limited to, the following:

- During the design stage of launching girder, particularly concerning the safety devices, precautions and requirements for the installation, erection, re-location and use of the launching girder.
- Task-specific and comprehensive risk assessments (in case of repetitive operations, the risk assessment may only be required prior to the first operation, with periodic reviews to ensure that no key factor has changed).
- Planning of the erection/re-erection, dismantling and re-location operations.
- Method statement (including safety rules/procedures) which shall be communicated in graphical format and in languages known to all workers involved in the lifting.

The method statement should cover but not limited to the following:

- All measures for avoiding or mitigating the hazards identified in the risk assessment.
- Step-by-step procedures supplemented with diagrammatic illustrations.

- Safety procedures and instructions.
- Procedures for avoiding hazards to personnel working adjacent to the operations.

Clear delineation of role and tasks of members of the working crew by written statements, and

- Arrangement for effective communications.
- Inspection, testing, thorough examination and maintenance of the launching girder.
- Means to ensure the availability of all necessary test and examination certificates operational and maintenance manual(s).
- Mechanical integrity program to ensure the proper design, erection/re-erection, re-location and operation of the launching girder.
- Approval of the launching girder's designer/manufacture for installation of additional accessories affecting safety or stability of the launching girder.
- Provision of properly trained and competent personnel who are aware of their respective responsibilities.
- Appointment of supervising engineer to supervise the operations of launching girder and the associated works in safe manner.
- Prevention of any unauthorized movement or use of the launching girder at all times.
- Contingency plans providing procedures to be followed in case of emergency situation including inclement weather.
- Provision of a log-book or else for entering the details of maintenance/repair works carried out on the launching girder; and
- If a specialist contractor is employed for the operations, involvement of such specialist contractor in the preparation of the method statement.
- Pre-use checking on structural safety after erection/re-erection of a launching girder shall be done by the engineer, who shall check the launching girder built against the specifications of the launching girder design.

- Defection checking to ensure the launching girder built conforming to the design specifications, and such checking is usually carried out by load testing the launching girder as per manufacturer/designer acceptance criteria.

Safe working loads and operating conditions

The launching girder shall not be used unless the safe working load is clearly and legibly marked on it in warranted circumstances, markings in appropriate language with respect to the working personnel should be made. Except for the purpose of enabling tests, the launching girder shall not be loaded beyond the maximum safe working load, which is specified in the current certificate of test and thorough examination delivered in the approved form by the competent examiner in respect of that launching girder.

Certifications needed;

The following documents should be made available before the launching girder is put into service:

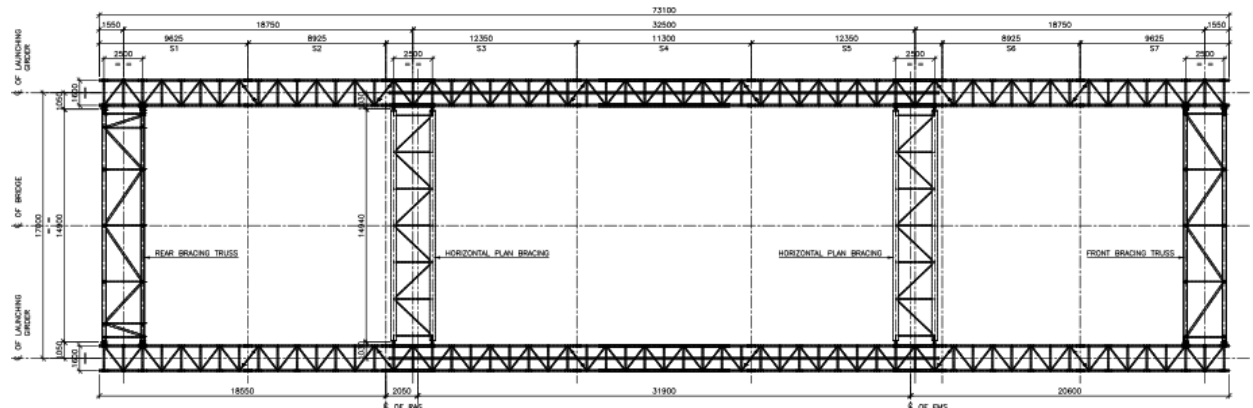
- Report on pre-use checking;
- Certifications of supporting structure;
- Risk assessment report on the operation and method statement;
- Record of the qualifications and experience of the supervising engineer, competent person competent workmen and Other personnel involved in the EDR and use of the launching girder;
- All test and thorough examination certificates; and
- Maintenance records/logbooks.

1814. MEASUREMENTS FOR PAYMENT

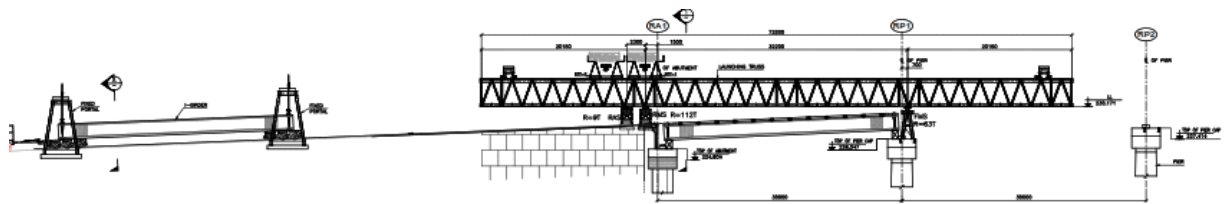
Launching shall be measured in **cubic meters**.

NNEXURE-1:

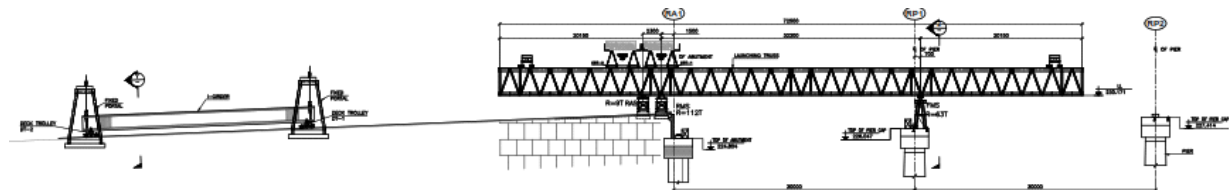
TYPICAL DOUBLE TRUSS TYPE LAUNCHING GIRDER FOR I GIRDERS



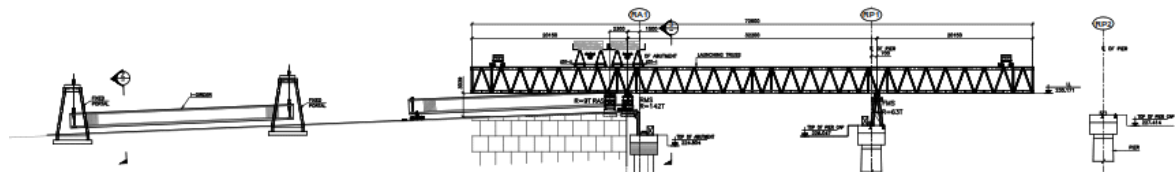
TYP. LAYOUT PLAN OF DOUBLE TRUSS LAUNCHING GIRDER.



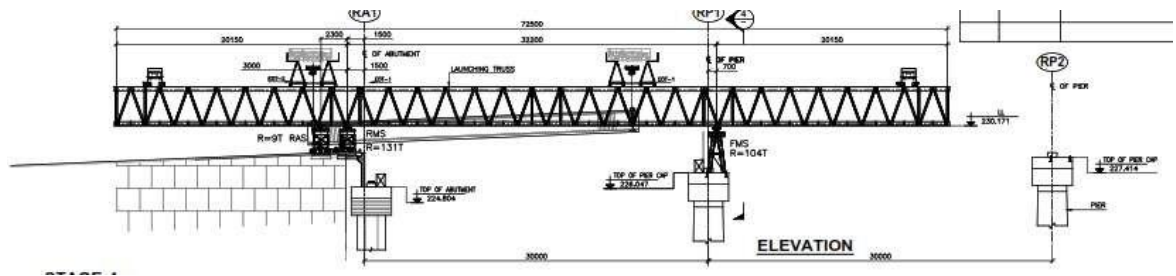
STAGE-01:



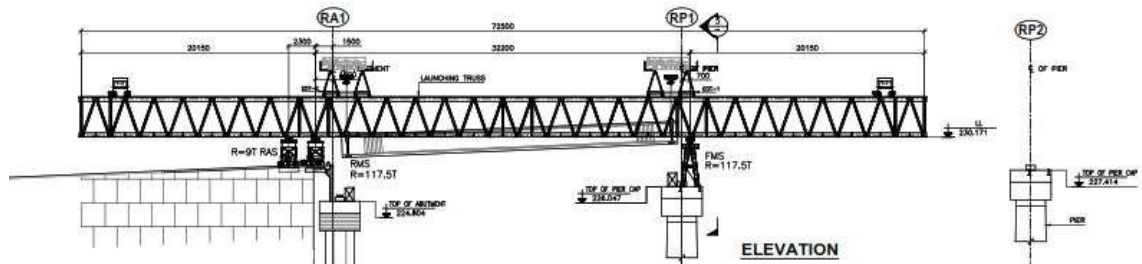
STAGE-02:



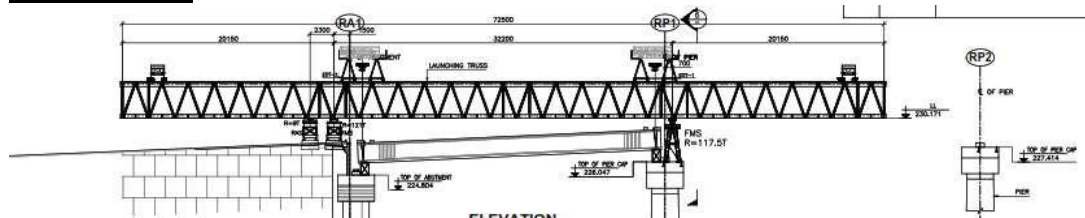
STAGE-03:



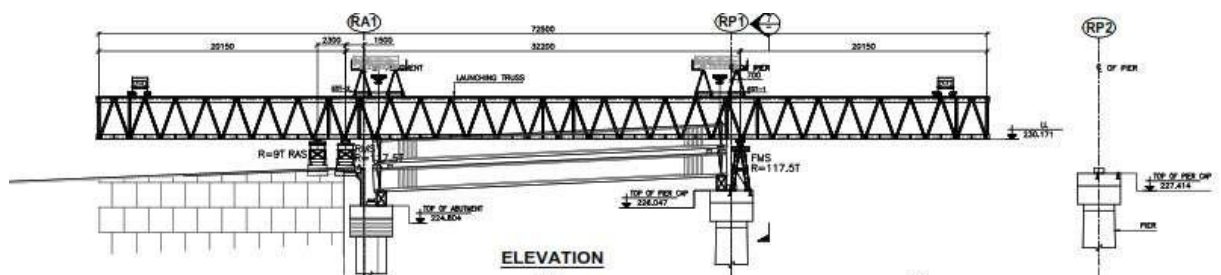
STAGE-04:



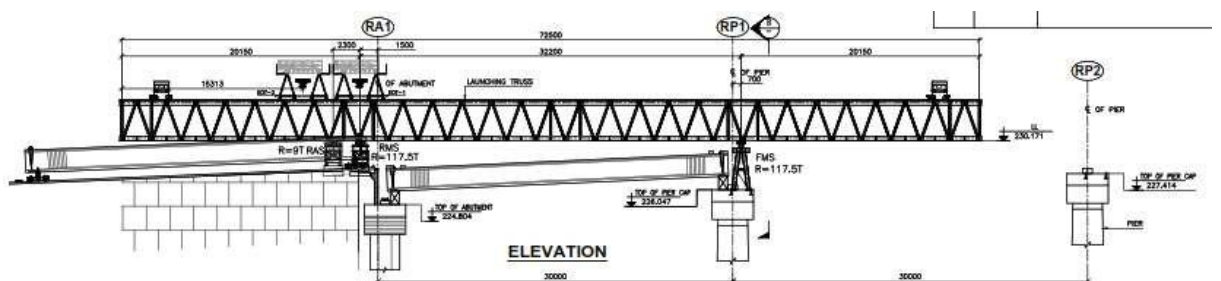
STAGE-05:



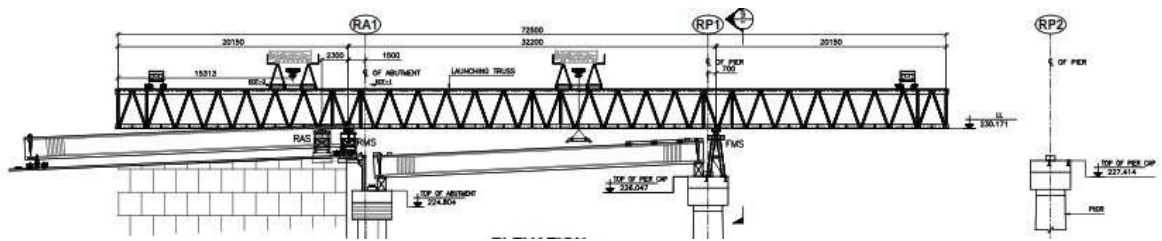
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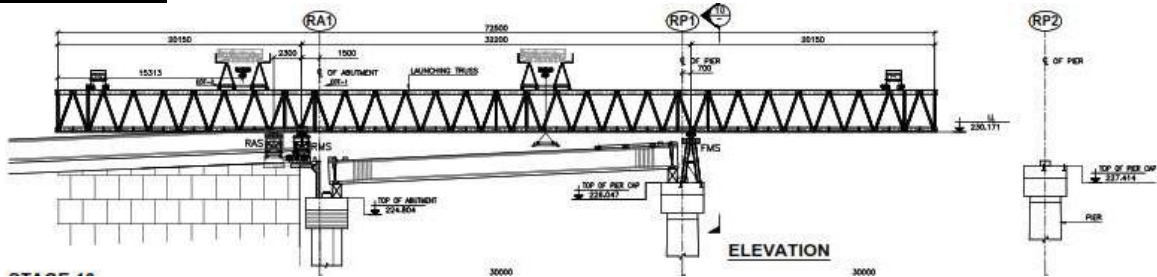
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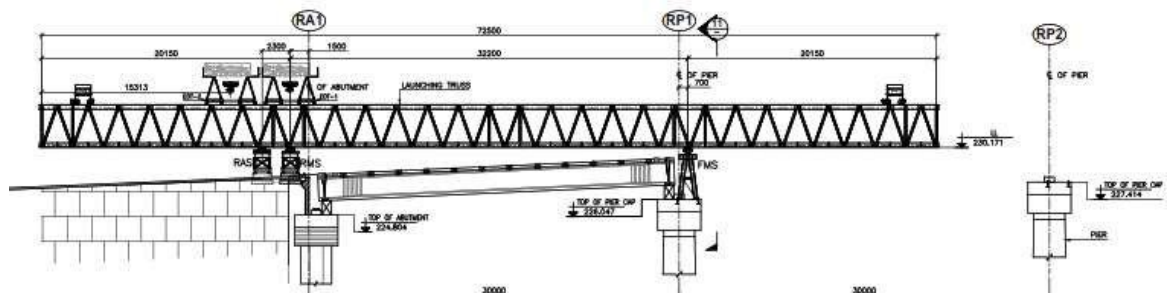
STAGE-08:



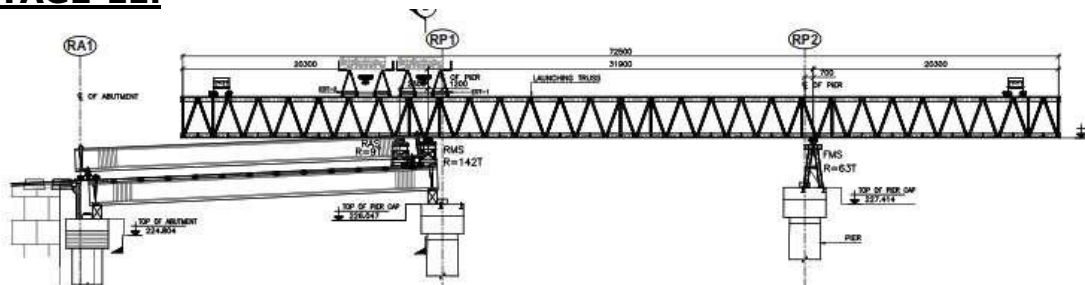
STAGE-09:



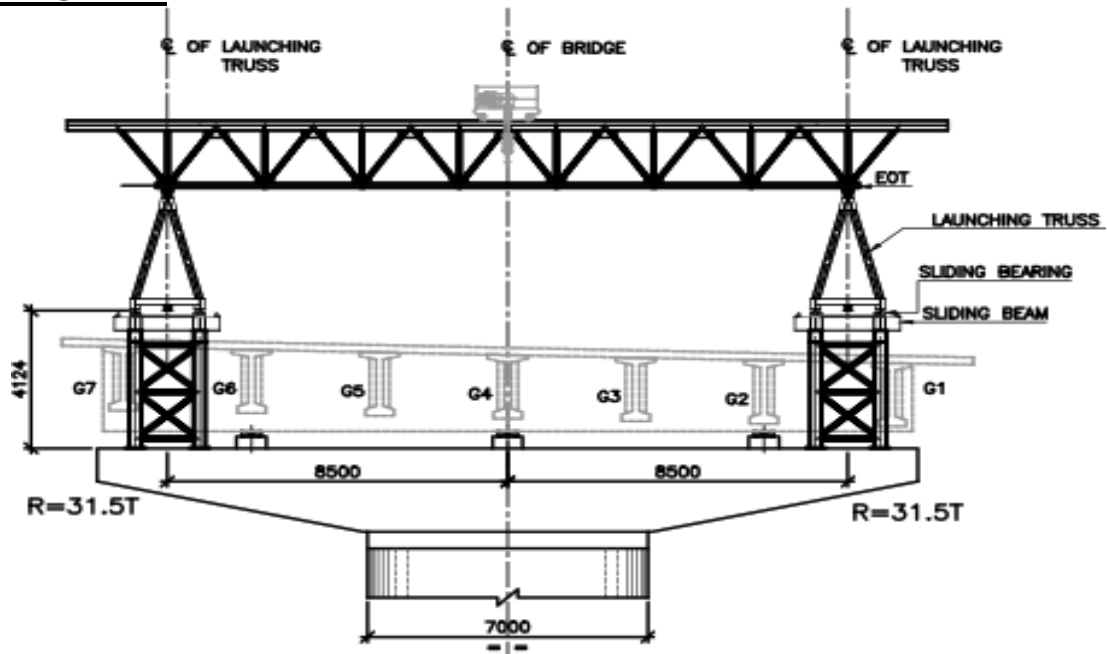
STAGE-10:



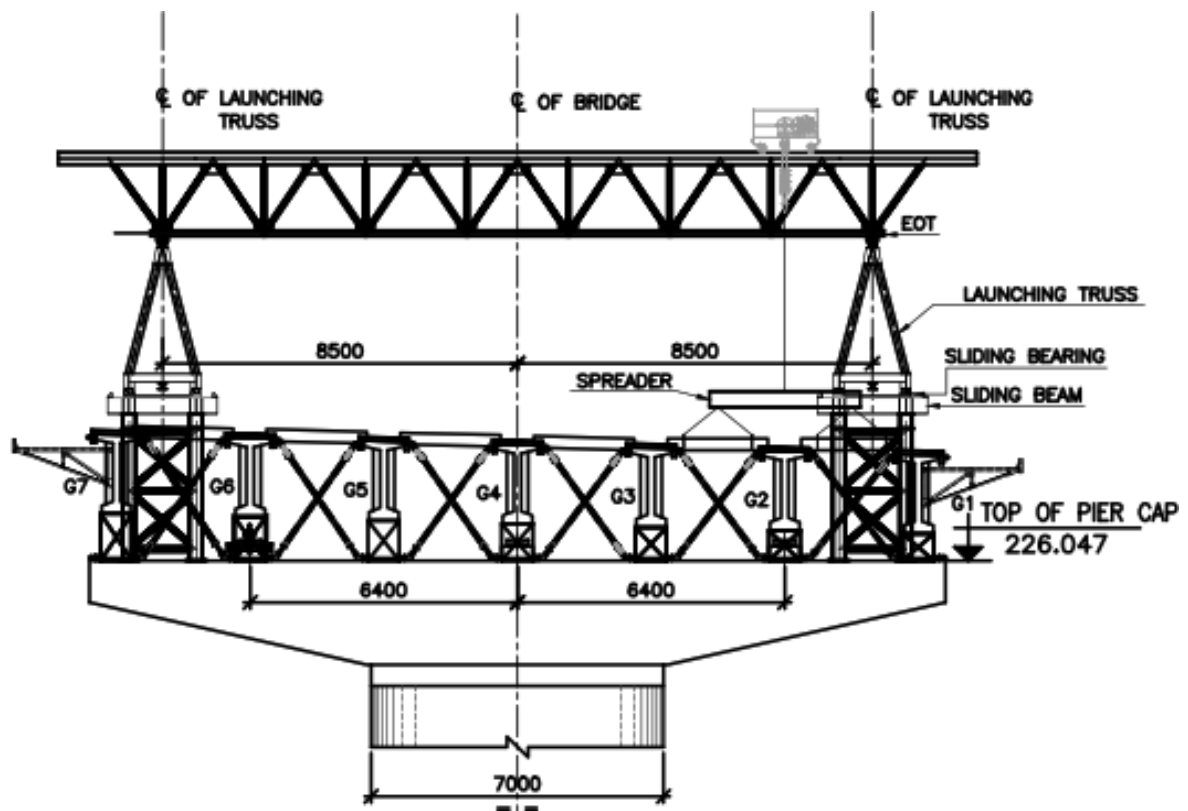
STAGE-11:



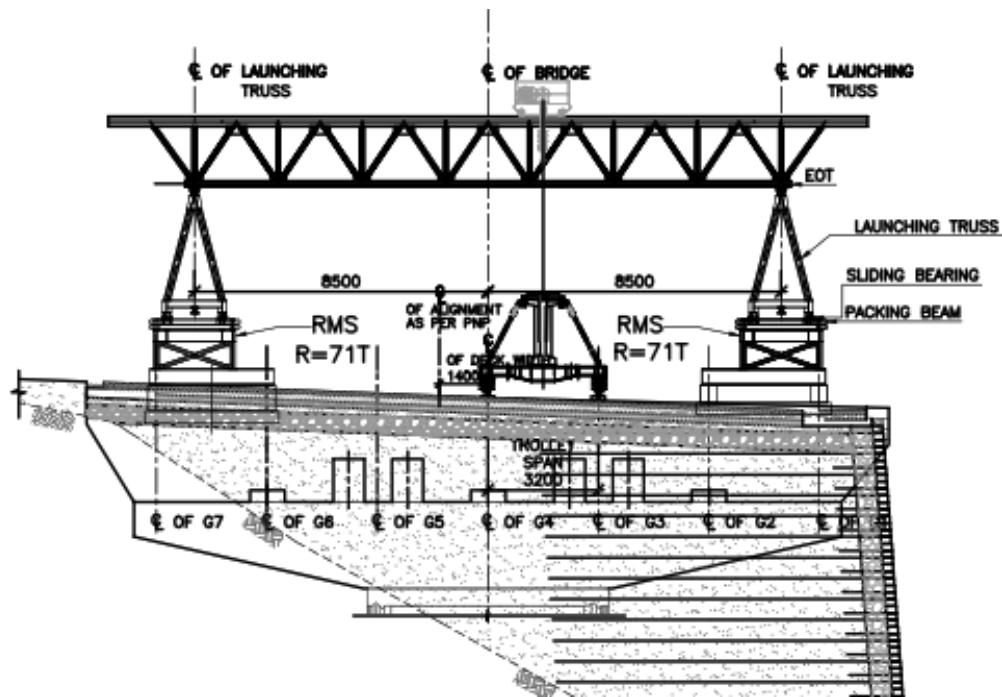
STAGE-12:



**TYP. SECTION OF FRONT MIDDLE SUPPORT(FMS)-
BEFORE GIRDER LAUNCHING**



TYP. SECTION OF REAR MIDDLE SUPPORT(RMS) – AFTER GIRDER LAUNCHING



**TYP. SECTION OF REAR MIDDLE
SUPPORT(RMS)**

Item No.16:- Providing and fixing in position Fe 550D TMT for R.C.C. bored piles as per detailed drawing, including cutting, bending hooking tying and welding complete and including forming the cage and lowering it in position. and including Providing fusion bonded Epoxy coating not less than 175 micron thickness and up to 300 micron to reinforcement bars as per IS-13620-1993/ASTM-775 M including testing of coating at plant and all taxes.

1601. GENERAL

This work shall consist of furnishing and placing T.M.T. reinforcement bars (intentioned) of the shape and dimensions shown on the drawings and conforming to these Specifications or as approved by the Engineer in charge.

1602. MATERIAL

1602.1. T.M.T. Bars

For Reinforced cement Concrete, the reinforcement steel as the case may be, shall consist of the following grade of reinforcing bars.

Table 1000-3 Grades of Reinforcing Bar

Grade Designation	Bar Type Confirming Governing Specifications	IS Characteristics Strength f_y Mpa	Elastic Modules GP
Fe 240	IS: 432 part I Mild Steel	240	200
Fe 415	IS: 1786 High Strength Deformed steel Bar (HSD)	415	200
Fe 500 or Fe 500D	IS: 1786 High Strength Deformed steel Bar (HSD)	500	200
Fe 550 or Fe 550D	IS: 1786 High Strength Deformed steel Bar (HSD)	550	200
Fe 600	IS: 1786 High Strength Deformed steel Bar (HSD)	600	200

All steel shall be produced from 'original procedure' who manufactures billets directly from iron ores and roll the billets to produced steel confirming to IS:1786 no re-rolled steel shall be incorporate in the works. However, in case the original producer give certificate that they are not producing bars of the required diameter, the engineer may allow the procurement of steel from other suppliers, provided that the reinforcement is manufactured from billets produced from original producers. In such cases, the manufacture's certificate alone shall not be considered as sufficient and the steel shall be got tested by the engineer in the NABL accredited laboratories only, as a third-party check. It shall be ensured that all the test result shall be confirmed to IS: 1786 requirements.

Only new steel shall be delivered to the site. Every bar shall be inspected before placing to its position and defective brittle or burnt bar shall be discarded. Bar with cracked ends of bars shall be discarded.

For the steel procured from original producers also, the Engineer/Employer may carry out occasional checks on materials through third party as mentioned above, for confirming the test results shown in the

certificates, in case of any doubt regarding the quality of steel supplied.

3.0. Pitch

3.1. Distance between bars shall be as specified in drawings and as directed by the Engineer in Charge all bars shall be placed at an accurate distance from each other and shall be bind tightly to maintain the desired pitch Suitable means shall be provided for holding bars securely in position

4.0. Binding wire

4.1. Mild steel binding wire shall be of 1.63 mm or 1.22 mm (16 to 18-gauge diameter and shall conform IS 280-1972

4.2. The use of black wire will be permitted for binding reinforcement bars. It shall be free from dirt, paint, grease or oil, oil scale or loose or thick rust and any other undesirable coating which may prevent adhesion of cement mortar at the time of binding

4.3. Only new binding wire shall be delivered to the site all binding wire shall be inspected before binding to its position and defective brittle, rusted, used wire, shall be discarded

1603 PROTECTION OF REINFORCEMENT

Uncoated reinforcing steel shall be protected from rusting or chloride contamination. Reinforcements shall be free from rust, mortar, loose mill scale, grease, oil or paints. This may be ensured either by using reinforcement fresh from the factory or thoroughly cleaning all reinforcement to remove rust using any suitable method such as sand blasting, mechanical wire brushing, etc. as directed by the Engineer. Reinforcements shall be stored on bricks, racks or platforms and above the ground in a clean and dry condition and shall be suitably marked to facilitate inspection and identification.

Portions of uncoated reinforcing steel and dowels projecting from concrete shall be protected within one week after initial placing of concrete with a brush coat of neat cement mixed with water to a

consistency, of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before placing of the adjacent pour of concrete. Coated reinforcing steel shall be protected against damage to the coating. If the coating on the bars is damaged during transportation or handling and cannot be repaired, the same shall be rejected.

1604 BENDING OF REINFORCEMENT

Bar bending schedule shall be furnished by the Contractor and got approved by the Engineer before start of work.

Reinforcing steel shall conform to the dimensions and shapes given in the approved bar bending Schedules.

Bars shall be bent cold to the specified shape and dimensions or directed by the Engineer using a proper bar bender operated by hand power to obtain the correct radius of bends and shape.

Bars shall not be bent or straightened in a manner that will damage parent material or the coating.

Bars bent during transport or handling shall, be straightened before being used on work and shall not be heated to facilitate straightening.

1605 PLACING OF REINFORCEMENT

a) The reinforcement cage should generally be fabricated in the yard at ground level, and then shifted and placed in position. The reinforcement shall be placed strictly, in accordance with the drawings and shall be assembled in position, only when structure is otherwise ready for placing of concrete. Prolonged time gap, between assembling of reinforcements and casting of concrete, which may result in rust formation on the surface, shall not be permitted.

b) Reinforcement bars shall be placed accurately in position as shown on the drawings. The bars, crossing one another shall be tied together at every intersection with binding wire (annealed), conforming to IS:280 to make the skeleton of the reinforcement rigid such that the reinforcement does not get displaced during placing of concrete, or any other operation. The diameter of binding wire shall not be less than 1 mm.

- c)** Bars shall be kept in position usually by the following methods:
- i)** In case of beam and slab construction, industrially produced polymer cover blocks of thickness equal to the specified cover shall be placed between the bars and formwork subject to Satisfactory evidence that the polymer composition is not harmful to concrete and reinforcement. Cover blocks made of concrete may be permitted by the Engineer, provided they have the same strength and specification as those of the member.
 - ii)** In case of dowels for pier and walls the vertical reinforcement shall be kept in position by means of timber templates with slots in them accurately, or with cover blocks tied to the Reinforcement Timber templates shall be removed after the concreting has progressed up to a level just below their location.
 - iii)** Layers of reinforcements shall be separated by spacer bars at approximately One meter intervals. The minimum diameter of spacer bars shall be 12 mm or: equal to maximum size of main reinforcement or maximum size of coarse aggregate, whichever is greater. Horizontal reinforcement shall not be, allowed to sag between supports.
 - iv)** Necessary stays, blocks, metal chairs, spacers, metal hangers supporting wires etc, or other subsidiary, reinforcement shall be provided to fix the reinforcements firmly in its correct position.
 - v)** Use of pebbles, broken stone, metal pipe, brick, mortar or wooden blocks etc as devices for positioning reinforcement shall not be permitted.
- d)** Bars coated with epoxy or any other approved protective coating shall be placed on supports that do not damage the coating. Supports shall be installed in a manner such that planes of weakness are not created in hardened concrete. The coated reinforcing steel shall be held in place by use of plastic or plastic coated binding wires especially manufactured for the purpose. Refer Section 1000 of these Specifications for other requirements.
- e)** Placing and fixing of reinforcement shall be inspected and approved by the Engineer before concrete is deposited.

1606 BAR SPLICES

1606.1 Lapping

All reinforcement shall be furnished in full lengths as indicated on the drawing. No splicing of bars, except where shown on the drawing; will be permitted without approval of the Engineer. The lengths of the splice shall be as indicated on drawing or as approved by the Engineer. Where practicable, overlapping bars shall not touch each other and shall be kept apart by 25 mm or 11 1/4 times the maximum size of coarse aggregate, whichever is greater, If this is not feasible, overlapping bars shall be bound with annealed steel binding wire, not less than 1 mm diameter and twisted tight in such a manner as to maintain minimum clear cover to the reinforcement from the concrete surface. Lapped splices shall be staggered or located at points, along the span where stresses are low.

1606.2 Welding

1606.2.1 Splicing by welding of reinforcement will be permitted only if detailed on the drawing or approved by the Engineer. Weld shall develop an ultimate strength equal to or greater than that of the bars connected.

1606.2.2 While welding may be permitted for H.Y.S.D. reinforcing bars conforming to IS:432, welding of deformed bars conforming to IS: 1786 shall in general be prohibited. Welding may be permitted in case of bars of other than S 240 grade including special. Welding grade of S 415 grade bars conforming to IS:1786, for which necessary chemical analysis has been secured and the carbon equivalent (CE) calculated from the chemical composition using the formula:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mg + V}{5} + \frac{Ni + Cu}{15}$$

is 0.4 or less.

1606.2.3 The method of welding shall conform to IS:2751 and IS:9417 and to any supplemental and clause 1904.8 of these specifications to the satisfaction of the Engineer.

Welding may be carried out by metal arc welding process. Oxy-acetelene welding shall not be permissible. Any other process may be used subject to the approval of the Engineer and necessary additional requirements to

ensure satisfactory joint performance. Precautions on over heating, choice of electrode, selection of correct current in arc welding etc., should be strictly observed.

All bars shall be butt welded except for smaller diameter bars (diameter of less than 20 mm) which may be lap welded. Single-V or Double-V joints may generally be used. For vertical bars single bevel or double bevel joints may be used.

Welded joints shall be located well away from bends and not less than twice the bar diameter away from a bend.

Generally, shop welding in controlled conditions is to be preferred, where feasible. Site welding where necessary shall, however, be permitted when the facilities, equipment, process, consumables, operators, welding procedure are adequate to produce and maintain uniform quality at par with that attainable in shop welding to the satisfaction of the Engineer.

Joint welding procedures which are to be employed shall invariably be established by a procedure specification. All welders and welding operators to be employed shall have to be qualified by tests prescribed in IS:2751. Inspection of welds shall conform to IS:822 and destructive or non-destructive testing may be undertaken when deemed necessary. Joints with weld defects detected by visual inspection or dimensional check inspection shall not be accepted. Suitable means shall be provided for holding the bars securely in position during welding. It must be ensured that no voids are left in welding. When welding is done in 2 or 3 stages, previous surface shall be cleaned properly. Bars shall be cleaned of all loose scale, rust, grease, paint and other foreign matter before carrying out welding. Oily competent and experienced welders shall be employed on the work with the approval of the Engineer. No welding shall be done on coated bars.

M.S. electrodes used for welding shall conform to IS:814.

1606.2.4. Welded joints shall preferably be located at points where steel will not be subject to more than 75 per cent of the maximum permissible stresses and welds so staggered that at any one section, not more than 20 per cent of the bars are welded.

1606.2.5. Welded pieces of reinforcement shall be tested. Specimens shall be taken from the site and the number and frequency of tests shall be as directed by the Engineer.

1606.3. MECHANICAL COUPLERS AND ANCHORAGES

1606.3.1 MECHANICAL COUPLERS

Bars may be joined with approved patented mechanical devices as indicated on the drawing or as approved by the Engineer e.g. by special grade steel sleeves swaged on to bars in end to end contact or by screwed couplers. In case such devices are permitted by the Engineer, they shall develop at least 125 per cent of the characteristic strength of the reinforcement bar.

1606.3.2 ANCHORAGES

Bars may be anchored with approved patented mechanical anchorages as indicated on the drawing or as approved by the Engineer. The anchorages shall be connected to the reinforcing bar by the use of taper thread system. The anchorages shall be capable of developing the characteristics strength of reinforcement without damage to concrete and shall have sufficient diameter and width to develop adequate shear cone strength. The connection shall develop 125% of the characteristics strength of reinforcement bar.

1607. TESTING AND ACCEPTANCE

The material shall be tested in accordance with relevant IS specifications and necessary test certificates shall be furnished. Additional tests, if required, will be got carried out by the Contractor at his own cost.

The supply, fabrication, furnishing and placing of reinforcement shall be in accordance with these specifications and shall be checked and accepted, by the Engineer.

Manufacturer's test certificate regarding compliance with Indian Standards for each lot of steel, shall be obtained and confirmatory tests in the presence of a person authorized by the Engineer. Cost of these tests shall be borne by the Contractor. The sampling and testing procedure shall be as laid down in IS: 1786. If any test piece selected from a lot fails, no re-testing shall be done and the lot shall be rejected.

1608. MEASUREMENTS FOR PAYMENT

Reinforcement shall be measured in length including hooks, if any, separately for different diameters as actually used in work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in **tonnes** on the basis of IS:1732. Wastage, overlaps, couplings: welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

1609. RATE

The contract unit rate for coated reinforcement shall cover the cost of material, fabricating, transporting, storing, bending, placing, binding and fixing in position as shown on the drawings as per these specifications and as directed by the Engineer, including all labour, equipment, supplies, incidentals, sampling, testing and supervision.

The unit rate for coated reinforcement shall be deemed to also include cost of all material, labour, tools and plant, royalty, transportation and expertise required to carry out the coating work as well as sampling, testing and supervision required for the work.

The rate shall be for a unit of **MT**.

Item No.17:- Providing and fixing in position Fe 550D TMT for R.C.C. Pile Cap as per detailed drawing, including cutting, bending hooking tying and welding complete and including forming the cage and lowering it in position. and including Providing fusion bonded Epoxy coating not less than 175 micron thickness and up to 300 micron to reinforcement bars as per IS-13620-1993/ASTM-775 M including testing of coating at plant and all taxes.

This work shall consist of **Providing and fixing in position of steel grade FE 550 D WITH FBEC for R.C.C. Pile Cap.** and shall be carried out as per relevant detailed specification of **Item No.16** of this contract.

The payment will be made on **M.T.** basis of the finished work.

Item No.18:- Providing and laying in position FE 550D TMT bar reinforcement including cutting, bending, hooking and tying complete as per detailed for the following. (A) Abutment cap & Dirt wall. (B) Pier Cap. and including Providing fusion bonded Epoxy coating not less than 175 micron thickness and up to 300 micron to reinforcement bars as per IS-13620-1993/ASTM-775 M including testing of coating at plant and all taxes.

This work shall consist of **Providing and fixing in position of steel grade FE 550 D WITH FBEC for (A) Abutment cap & Dirt wall. (B) Pier Cap.** and shall be carried out as per relevant detailed specification of **Item No.16** of this contract.

The payment will be made on **M.T.** basis of the finished work.

Item No.19:- Providing and placing in position FE 550D TMT bar reinforcement including cutting, bending, hooking, and tying complete as per detailed drawing.(B) T-Beam and Deck slab type of superstructure (I) Deck slab (II) Main and cross Girder and including Providing fusion bonded Epoxy coating not less than 175 micron thickness and up to 300 micron to reinforcement bars as per IS-13620-1993/ASTM-775 M including testing of coating at plant and all taxes.

This work shall consist of **Providing and fixing in position of steel grade FE 550 D WITH FBEC .(B) T-Beam and Deck slab type of superstructure (I) Deck slab (II) Main and cross Girder** and shall be carried out as per relevant detailed specification of **Item No.16** of this contract.

The payment will be made on **M.T.** basis of the finished work.

Item No.20:- Providing and fixing in position to exact profile high tensile steel wires of required ultimate strength including bending, cutting, tying providing necessary standard and anchorages, sheathing, stressing, grouting, ducts as per detailed drawing including necessary plant and machinery complete.

1. All wires or bars shall be assigned a lot number and shall have suitable tags for identification. All samples shall be truly representative of the lot to be furnished and in the case of wire or strand, they shall be taken from the same master roll. All materials specified for testing shall be furnished as per instructions of Engineer-in-charge, free of use. When High Tensile steel wires are brought by the Contractor, he shall produce all relevant certificates from the manufactures. Additional tests if required by the Engineer-in-charge, shall be got conducted by the Contractor at his cost, through an independent agency approved by the Engineer-in-charge.
2. Sheaths shall be manufactured from Bright Galvanised metal sheet or any other specified material. They shall be preferably machine made and of a large enough bore to allow easy threading of the cable or bar in long lengths. They shall be strong enough as not to be dented or deformed during handling or concreting.
3. Preferably proprietary forms of anchorages shall be used and they shall be strictly in accordance with the manufacturer's instructions. If the Engineer-in-charge so desires, few anchorage cones shall be got tested by the Contractor at his own cost. The anchorage shall be furnished, complete with distribution plates of each size of type to be used, free of charge, for resting.
4. Cement for grouting shall conform to relevant specifications but rapid hardening Portland cement may be used at temperatures less than 7.2°C. Sand, where used for large ducts, shall be of a size smaller than 2 mm. additives (Plasticizers) shall be used only when experience has shown that their use improves the quality of the grout. They shall contain no chloride or nitrate or any other ingredient which may induce corrosion of steel. The compressive strength of the grout at 7 days measured on 100 mm. cubes, shall be at least 175 kg/sq.cm. The test cubes shall be cured .in a moist atmosphere for 24 hours and subsequently in water.
5. All prestressing steel shall be free from loose mill scale, rust, oil, grease or any other harmful matter at the time of its placing in the member. Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing, or passing through a pressure box containing carborundum powder.
6. As far as possible prestressing wire shall be obtained from the manufactures in coils having diameter of not less than 350 times the diameter of the wire itself, so that the wire springs back straight on being uncoiled. If due to smaller of the coil or any other reason it does not happen the wire shall be straightened before use. Prestressing steel bars, may be obtained from the manufacturers in straight condition. Any small adjustments-necessary because of site conditions shall be made by bending in a normal type bar bender. Bars shall not be bent when their temperature is less than 10°C.
7. Prestressing steel shall be accurately located and maintained in position, both vertically and horizontally, as per drawings. The method of supporting and fixing shall be such that profile of cables is not at all disturbed by heavy and

- prolonged vibrations, by pressure of wet concrete, by workmen or by construction. The steel sheaths or duct formers shall be suitably tied to secondary reinforcement or to properly located withdraw ably through shutter bolts, precast concrete blocks or similar effective means, in such a manner that they do not give rise to excessive friction when the steel being tensioned.
8. All cutting to length and trimming of ends shall be done by suitable mechanical or flame cutters, when a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel. In post-tensioning ends of prestressing steel projecting beyond the anchorages shall be cut after the grout has set. Welding of prestressing steel shall not be permitted, internal prestressing steel shall be protected by grouting as detailed in above. External prestressing steel shall be protected by encasing it in a dense concrete cover secured to the main concrete.
 9. Sheaths shall be sufficiently water tight to prevent concrete laitance penetrating them in quantities likely to increase friction. Special care shall be taken to ensure water tightness at joints. Anchor cones, blocks and plates shall be positioned, and maintained during concreting so that the centre line of the duct passes axially through the anchorage assembly. All bearing surface of the anchorages shall be cleaned prior to concreting and tensioning. Adequate provision shall be made for protection of the anchorages against corrosion.
 10. It shall be ensured that all necessary equipment for prestressing is available at site of work. The prestressing shall be carried out with approved jacking equipment. The tensioning apparatus shall satisfy the following requirements
 - (i) The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.
 - (ii) Where two more wires are stressed simultaneously, provision shall be made for equal stressing of the wires;
 - (iii) The tensioning apparatus shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel anchorage or concrete:
 - (iv) Means shall be provided for direct measurement of the force in prestressing steel during stressing or gauges filled in the hydraulic system itself to determine the pressure in the jacks. Facilities in such a case shall be provided for the measurement of the extension of prestressing steel and of any movement of the gripping devices at transfer.
Combination of the jack and the gauge shall be calibrated and a graph or table showing the calibration shall be furnished and got approved from the Engineer-in charge prior to the commencement of work. Calibration of gauges of the jacks shall be done at suitable intervals, the prestressing equipment shall be checked to determine any variation from the normal values during use. So far as these variations depend upon external influence (e.g , temperature in the case of oil jacks) they shall be taken into account. Any equipment which gives an error in values of more then $< 5\%$ shall not be used on the works.
 11. All reasonably precautions shall be taken when working with or near steel which has been tensioned or is in the process-of being tensioned. Person shall not stand in line with the steel; anchorages or the jacking equipment, neither shall they walk on the steel. Simple protective measures such as stout timber shields armoured with steel shall be placed in line with prestressing steel and

behind the jacks so as to protect personnel crossing in the course of their duties. In all cases, cable extension and the prestressing force to be applied shall be worked out in advance after allowing for all the factors like; (i) tensioning in stages; (ii) hindrance to elongation on account of friction due to non-rectilinear alignment of the prestressing elements; (iii) slip in the anchorages; and (vi) creep; and an approved record of the same shall be kept. The change in length of the cables as well as the tensioning force shall be measured at the time of tensioning and it shall be proved by comparison that the losses allowed for are not exceeded. Tensioning shall be carried out under competent supervision in such a manner that the stress in the steel increases at a gradual and steady rate. When stressing from one end only, the pull at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end. No tensioning of bars shall be carried out when the temperature is less than 2°C.

12. Where wires in a cable are not stressed simultaneously spacing members shall be sufficiently rigid so as not to be displaced during the successive tensioning operations. Wires and cables, shall be so arranged that they do not pass round sharp corners or bends to avoid setting up of stresses likely to provide rupture. Tensioning shall be conducted in such a manner that the applied tension and elongation can be measured at all times. It shall be ensured that in no case the load is applied to the concrete before it attains the specified strength. To determine the specified strength additional cube test shall be conducted at contractor's cost. After the steel has been anchored, the force exerted by the tensioning apparatus shall be decreased gradually and steadily so as to avoid shock to the prestressing steel or anchorage.
13. Vents shall be provided at all crests and valleys in the duct profile and at intervals of not more than 15 meters in straight reaches. Threaded entries shall be provided at the duct ends to permit use of a screwed connector from the grout pump. Before grouting, the ducts shall be thoroughly cleaned and shall be free of water, any dirt or other foreign substances. Ducts formed without metal sheathing shall be flushed with water before grouting, and all surplus water removed by compressed air injection. The anchorages shall be thoroughly sealed with mortar of strength equal to that of the grout to prevent ingress of air into the duct during grouting operation. The equipment shall be capable of producing a grout of colloidal consistency, by means of high frequency turbulence but imparting only a slow motion to the body of the grout. It shall have delivery pressure of up to 7 Kg/cm² and be capable of continuous operation without any appreciable pressure variation and include a system for recirculating the grout while actual grouting is not in progress. The piping shall have a minimum of bends, valves and changes in diameter, the baffles shall be fitted with sieve strainers 2 mm in size. The equipment, and in particular the piping, shall be thoroughly washed with clean water after every operation and more frequently if necessary. Water shall be added to the mixer first and then the cement. After these have been thoroughly mixed, sand and the additive, if any, shall be added. The water content of the mix shall be kept as low as possible and the water/cement ratio of 0.40 will be preferable when using a neat cement grout. The approximate proportion of the mix shall be one part cement to 0.74 part sand, the exact proportion being adjusted to form a grout giving proper consistency. Mixing shall continue for at least 2 minutes until a uniform consistency is obtained. Injection shall be

continuous. Grout shall be allowed to flow from vent openings until its consistency at exit is equivalent to that of the grout injected. The vent opening shall thereafter be firmly closed one after another in the direction of flow. Sufficient pressure shall be used to force the grout completely through the duct, care being taken not to rupture the ducts. Grouting shall be carried out as soon as practicable after the steel has been stressed. The injection tubes shall be topped up with cement grout if any wastage or subsidence of grout occurs when the pump is disconnected. When grouting is done at temperature below 7 °C. provision shall be made for thoroughly protecting the concrete member against frost. Grouting is not recommended in very cold weather

14. To provide for any deficiency in the prestressing, free stand- by cables shall be provided in the girders and the same shall not be paid for even if they are used in the girder. Stand by cable will be permitted to be withdrawn if not required to be-stressed.
15. For the purpose of measurement, the length of the high tensile steel shall be measured as actually used in the finished work. From the length so measured its weight shall be calculated in **MT.** as per IS : 1732 Anchorage devices, ducts or metal sheath shall be deemed to be included in the item of high tensile steel and shall not be measured separately.
16. The item rate for high tensile steel cover the cost of all materials, labour, tools and paint required for fixing, placing, tensioning, anchoring, and grouting the high tensile steel in the prestressed cement concrete as shown on the drawings. The cost of anchoring devices and ducts or metal sheath shall also be included in this rate. The Item shall be measured & paid on tonnage basis.

Item No.21:- Supplying, fitting and fixing in position true to line and level elastomeric bearing conforming to IRC: 83 (Part-II) section IX and clause 2005 of MoRTH specifications complete including all accessories as per drawing and Technical Specifications.

1. The term 'bearings' in this case shall refer to an elastomeric bearing consisting of one or more elastomer slabs bonded to metal plates during manufacture so as to form a sandwich arrangement, while 'Bearings Pads' shall denote single unreinforced elastomer slabs.
2. The elastomer to be used for bearings shall be made from natural or synthetic rubber and satisfy the physical properties given below. The test pieces required for the tests shall be selected from the centre layer of the bearings while making up the selection.

Sr. No.	Items	ASTM Designation	Requirement
(i)	Durometer Hardness	D – 2240	55 to 70

(ii)	Ultimate Tensile Strain percent	D - 412	450 for 55 grade, 400 for 60 grade 300 for 70 grade
(iii)	Tensile Strength Kg/Sqcm	D -412	175 Minimum 135 minimum for natural rubber of hardness greater than 65
(iv)	Adhesion to Metal Kg/cm	D – 429 (Method B)	9
(v)	Tear Resistance Kg/cm	D – 624 40 (DIEC)	
(vi)	Compression set 22 hrs. at 70 °C%	D – 395 (Method B)	25 maximum
(vii)	Ozone resistance 22% strain 100 hrs. at 380 ° C \pm 10 ° C (1 part per million in air by volume)	D – 1149	No craks
(Viii)	Accelerated ageing 70 hours, 1000C Hardness increase Tensile strength reduction, Elongation at break reduction	D – 573	10 points 15 % of original 25 % of original
(ix)	Low temperature stiffness young's modulus – 40 ° C Kg/Sq.cm	D – 797	700 maximum

3. Adhesive used in bearing location or attachment to bridge decks shall be subject to the approval by the Engineer in-charge. It shall be of high viscosity resins, which are cold setting and free of solvent. Adhesive shall not be used to bond layers of cured elastomer. Mild steel used for plate reinforcement shall comply with the requirements of relevant I.S. The Contractor shall furnish to the Engineer in-charge a certificate by the Manufacturer that the elastomer and fabric (if used) in the elastomeric bearing conforms to all the above requirements. The certification shall be supported by a certified copy of the results of tests, performed by the Manufacturer upon samples of the elastomer and fabric to be used in the bearings.

The contractor shall, whenever required, during the course of manufacture arrange and offer all facilities for the purpose of inspection

and test of all or any of the material used therein, to any officer as directed by the Engineer-in-charge and the bearings and similar parts shall be used in the superstructure except on the production of certificate of acceptance thereof from the Directorate of Inspection whenever necessary. All the inspection charges shall be payable by the contractor.

4. The thickness of a single layer bearing shall not exceed 20 percent of the least plan dimension. The thickness of any internal layer of elastomer shall not be less than 6 mm. nor greater than 12 mm. The thickness of outer plates shall be not less than 3 mm. and that of inner plate not less than 1.5 mm. Metal plates in which dowels are located shall be, in general, not less than 6 mm. thick. The edges of all plates shall be lightly rounded to approximately 5 mm. The metal plates referred above should not be composed of thinner plates joined together. Laminated Bearings shall have side cover of elastomer of minimum thickness of 6 mm. to protect the ends of the steel plates and to give a reduced surface strain to that occurring at the edge of the bonded plates but shall not be considered in evaluation of deformations. The cover of elastomer at the top and bottom surfaces shall not be less than 3 mm. or more than half the thickness of internal layer. The outer cover at top and bottom surfaces having thickness less than half that of a single internal layer and not exceeding 3 mm. may be considered as a simple protection and need not therefore be considered in calculating deflections. Where above elastomer covers are provided, there is no objection to keeping the thickness of top most and bottom most plates same as that of inner plates.

5. Bearing shall be set back from the edge of a bearing surface a distance not less than the thickness of the layer of elastomer in contact with bearing surface to allow for spreading of the elastomer under load. Bearings may be located in position by means of dowels or studs or other devices, or bonded to the structure with approved adhesives which shall generally be of the high viscosity resin type cold setting and free from solvent. For spans on an inclined grade and without hinge bearings the sole plates shall be provided and the same beveled so that masonry surfaces and the bearing shall be kept horizontal. To facilitate maintenance, the ends of trusses and plate girders shall preferably be supported on plates or pedestals so that there is at least 15 centimeters clearance between the bottom chord or flange and the substructure. The plan dimensions of the bearings to be finally adopted shall preferably be

selected from series 'R' 20 of IS : 1076. The arrangement of placing only one bearing under a girder shall be permitted. Further, bearings of different sizes must not be placed next to each other to support a span. The bearings shall be fully moulded when metal laminations are used. These laminated elastomeric bearings shall consist of one or more elastomer slabs bonded to metal plates so as to form a sandwich arrangement. Such fully moulded bearings shall be manufactured to required size. The bond between elastomers and metal or fabric shall be such that, when a sample is tested for separation, failure shall occur within the elastomers and not between the elastomer and metal.

6. The contractor shall get the bearings tested for the physical properties and performance of bearings. The test pieces required for the test shall be selected from the Central layer of bearing making up the selection. For the Size of the test pieces and method of tests etc. the relevant A.S.T.M. Standard shall be followed. The tests shall be carried out in a recognized laboratory acceptable to the department for all the necessary tests required by the Department. The specimen for tests as may be required shall be supplied by the contractor at his own cost and the testing charges shall also be fully borne by the contractor. Only those bearings which pass the tests satisfactorily will be accepted and will be permitted to be used. The Department shall not accept any responsibility for the cost of bearings rejected.

7. (i) Tolerances on length and width 0.5 mm.

(ii) Tolerances on thickness for single layer pad. ± 0.5 mm.

(iii) Tolerance on total thickness 'h' of finished bearings.

$10 < h \leq 30$ mm	:	± 0.5 mm.
$30 < h \leq 50$ mm	:	± 0.8 mm.
$50 < h \leq 80$ mm	:	± 0.9 mm.
$80 < h \leq 120$ mm	:	± 1.1 mm.

(iv) The parallelism of the individual elastomer laminations for a finished bearing, shall not exceed the tolerances specified at (ii) above when measured at the extremities of the laminations.

8. Proper arrangement shall be made to avoid corrosion of metal plates or deteriorating of adhesive by encasing the bearings totally in elastomer or by some other method approved by the Engineer-in-charge.

9. (i) When bearing assemblies on plates are shown on the drawing to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade and shall be finished by grinding.
- (ii) It shall be ensured that bearings are set truly level and in exact position as indicated on the drawings so as to have full and even bearing on the seats. Thin mortar pads (not exceeding 12 mm.) may be made to meet with this requirements.
- (iii) It shall be ensured that the bottoms of the girders to be received on the bearings are plane at the location of these bearings and care shall be taken that the bearing are not displaced while placing the girders.
- (iv) Before fixing the elastomeric bearings the concrete surface on which the bearings is to be placed shall be wood float finished to a level plane which shall not vary more than 1.5 mm from a straight edge placed in any direction across the area
- (v) The position of the bearings shall be accurately marked on the pier/abutment cap and the area where the bearings are to be located levelled accurately.
- (vi) The concrete surface shall be free from any loose material and cleared of any grease oil, paint etc., and it shall be dry at the time of fixing.
- (vii) The surface of elastomer shall be free from any foreign material.
- (viii) Once prepared, the concrete or elastomer shall not be touched with bare hand.
- (ix) The bearings shall be covered with canvas or a suitable covering material to protect from direct sun-light and weather until the concrete on superstructure is cast
- (x) The bearings shall be fixed in position with epoxy resin adhesive of approved quality.
- (xi) The concreting of superstructure shall be taken up only after ensuring that the adhesive for fixing the bearings or pier/abutment cap has set.
10. Unit rate shall be cubical contents of the bearing measured in Cu.cm.
11. The rate for each type of bearings shall include the cost of supplying and fixing the bearings in position complete. The rate shall also include the cost of samples and their testing as desired by the Engineer-in-charge. The rate shall also include the cost of adhesives for fixing them.

2005 ELASTOMERIC BEARINGS

Elastomeric bearings shall cater for translation and/or rotation of the superstructure by elastic deformation.

2005.1 Materials

- i) Chloroprene Rubber (CR) only shall be used.
- ii) Grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life viz. Neoprene WRT, Neoprene W, Bayprene 110, Bayprene 210, Skyprene B-5, Skyprene B-30, Denka S-40V and Denka M-40, shall be used.
- iii) No reclaimed rubber or vulcanized wastes or natural rubber shall be used.
- iv) The polychloroprene content of the compound shall not be lower than 60 per cent. The ash content shall not exceed 5 per cent of its weight. Polychloroprene content shall be determined in accordance with ASTM D297 and ash content as per IS:3400-Part XXII.
- v) Use of synthetic rubber-like materials such as Ethyl Propylene Dimonomer (EPDM), Isobutane Isoprene Copolymer (IIR) and Chloro Isoprene Copolymer (CIIR) shall not be permitted.

2005.1.2 Properties of Elastomer

The elastomer shall conform to the properties specified in Table 2000-1.

Table 2000-1 : Properties of Elastomer

Property	Unit	Value of the Characteristic Specified			Test Method IS Specification Reference
(1)	(2)	(3)			(4)
1. Physical properties 1.1	IRHD	50 ±	60 ± 5	70 ± 5	IS:3400 (Part II)
1.2 Minimum tensile strength - Moulded test piece	MPa	17 14	17 14	17 14	IS:3400 (Part I)

1.3 Minimum elongation at break					
- Moulded test piece		450	400	300	IS:3400 (Part II)
- Test piece from bearing	%	400	350	250	IS:3400 (Part II)

Property	Unit	Value of the Characteristic Specified	Test Method IS Specification Reference
(1)	(2)	(3)	(4)
Maximum compression set (%) (24 h, 100 ± 1 °C)	%	< 35	IS:3400 (Part X)
Accelerated aging (72 h, 100 ± 1 °C) (Maximum change from unaged value)			IS:3400 (Part IV)
3.1 Maximum change in hardness	IRHD	± 5	
3.2 Maximum change in tensile strength	%	± 15	
3.3 Maximum change in elongation	%	± 30	

2005.1.3 Shear modulus (G) is the apparent "conventional shear modulus" of the elastomer bearing determined by testing. At nominal temperature of 23 °C ± 2°C, the value of G shall comply with the values given in **Table 2000-2**.

Table 2000-2 : Shear Modulus at Nominal Temperature

Hardness (IRHD)	G (MPa)	Tolerances of G (MPa)
(1)	(2)	(3)

50 ± 5	0.7	±0.15
60 ± 5	0.9	±0.18
70 ± 5	1.15	±0.20

2005.1.4 The adhesion strength of elastomer to steel plates determined according to IS:3400 (Part XIV) method A, shall not be less than 7 Kn/m.

2005.1.5 For elastomeric bearings (CR) used in adverse climatic conditions, the ozone resistance of elastomer shall be proved satisfactory when assessed by test according to IS:3400 (Part XX). The testing shall be carried out for a duration of 96 hours at a temperature of 40±1°C, strain of 30 per cent and ozone concentration of 100 pphm by volume.

If any cracking is detected by visual observation at the end of the test, the material shall be considered unsatisfactory. **No** specific tests for assessment of low temperature resistance are deemed necessary.

Note:

For use of elastomer in extreme cold climates, the Engineer may specify special grade of low temperature resistant elastomer in conformity with operating ambient temperature conditions. The specifications for such special grade elastomer including the tests for low temperature resistance, shall be mutually agreed by the

2005.1.6 Laminates of mild steel conforming to IS:2062/IS:1079 or equivalent international grade, shall only be permitted. The yield stress of the material shall not be less than 250 MPa. Use of any other material like fiber glass or similar fabric as laminates, shall not be permitted.

2005.1.7 The manufacturers of elastomeric bearings shall satisfy the Engineer that they have in-house facilities for carrying out the following tests on elastomer in accordance with the relevant provisions of ASTM D-297.

- a) Identification of : to confirm the usage of
polymers chloroprene (Appendix X-
2)
- b) Ash content : to determine the
percentage

- | | |
|---------------------|--------------------|
| | (sub-section 34) |
| c) Specific gravity | : (sub-section 15) |
| d) Polymer content | : (sub-section 10) |

The Engineer shall invariably get the test (a) performed in his presence or in the presence of his authorized representative. In case of any dispute regarding interpretation of results, the Engineer may carry out test as per ASTM S-3452-78 (chromatography test) at the manufacturer's cost in a recognized test house. The elastomer specimen to conduct the test shall be obtained from the bearing selected at random for destructive test. The remaining part of the test bearing shall be preserved by the Engineer for any test to be done later, if required.

2005.2 Manufacturing and Workmanship

- i) Plain pad and strip bearing shall be moulded in one piece, or comprise single pieces cut from previously moulded strips or slabs. Cutting shall produce a smooth surface without injurious heating of the elastomer.
- ii) Bearing with steel laminates shall be moulded as a single unit in a mould and vulcanised under heat and pressure. Moulding of elements in separate units and subsequent bonding as well as cutting from large sized cast, shall not be permitted.
- iii) The moulds used shall have standard surface finish adequate to produce bearings free from any surface blemishes.
- iv) Steel plates for laminates shall be sand/grit blasted, clean of all mill scales and shall be free from all contaminants prior to bonding by vulcanization. Rusted plates with pitting shall not be used. The plates shall be rounded so as to be free of sharp edges.
- v) Bonding shall be carried out during vulcanization using suitable bonding agent for bonding of elastomer to steel such that the bond peel strength is at least 7 N/mm width when tested in accordance with IS:3400 Part XIV method A.

- vi) Spacers used in mould to ensure cover and location of laminates shall be of minimum size and number practicable. Any hole at surface or in edge cover shall be filled in subsequently.
- vii) Care shall be taken to ensure uniform vulcanizing conditions and homogeneity of elastomer through the surface and body of bearings.
- viii) The vulcanizing equipment/press shall be such that between the platens of the press, the pressure and temperature are uniform and capable of being maintained at constant values as required for effecting a uniform vulcanization of the bearing.
- ix) The moulding dies utilized for manufacturing the bearings shall be so set inside the platen of the press that the pressure developed during vulcanization of the product is evenly distributed and the thickness maintained at all places are within acceptable tolerance limits taking into consideration the expansion/shrinkage allowance of vulcanized (the product of vulcanization).
- x) The raw compound which is introduced inside the metal dies for vulcanization shall be accurately weighed each time and shall be of sufficient quantity to ensure proper flow of material to every part of the die so that a homogeneous and compact bearing is produced without any sign of sponginess or deficiency of material at any place.
- xi) Before the rubber mix of any batch is used for producing vulcanized bearings, test pieces in the form of standard slab and buttons shall be prepared in accordance with prescribed standards and salient properties tested and recorded regularly against each batch of production to monitor the quality of the products.
- xii) Bearings of similar size to be used in a particular bridge project shall be produced by identical process and in one lot

as far as practicable. Phased production may be resorted to only when the total number of bearings is large.

2005.3 Manufacturing Tolerances

The bearings shall be fabricated/manufactured with the tolerances specified in Table 2000-3. Tolerances of thickness of individual layer of elastomer, dimension of laminates, and flatness of laminates are primarily meant for quality control during production. In order to measure thickness of individual layer of elastomer, dimension of laminates and flatness of laminates of a finished bearing, it is essential to cut the bearing, which may be done if agreed upon between the manufacturer and the buyer.

Table 2000-3: Tolerances

	Items	Tolerances
	Overall linear plan dimensions	-3 mm, +6 mm
	Total mean bearing thickness (The mean thickness is the arithmetic average of the thickness measured at five points on the major surface as indicated for various shaped bearings: Rectangular: corners and centre Circular: corners of inscribed square and centre)	-2.5%, +5%
	Parallelism Of top surface of bearing with respect to the bottom surface as datum Of one side surface with respect to the other as datum	1 in 200 1 in 100
	Thickness of individual layer of elastomer Inner layer of elastomer Outer layer of elastomer Side cover	±12% (max of 2 mm) +20% (max of 1 mm) -0 mm, +3 mm

	Dimension of laminates Plan dimensions of laminates Thickness of laminate Parallelism of laminate with respect to bearing base as datum (with respect to diameter for plates circular in plan and shorter side for plates rectangular in plan)	-3 mm, + 0 ± 10% 1 in 100
	Items	Tolerances
6)	Flatness Flatness shall be assessed by placing a straightedge along the diagonal or diameter. The gap between the straightedge and the surface shall not exceed the tolerances specified below Load bearing surface of the bearing Steel laminate	0.3% of diameter or diagonal or 2% of mean bearing thickness which ever is higher 1% of diameter or (max of 1.5 mm)

2005.4 Acceptance Specifications

The manufacturer shall have all the test facilities required for the process and acceptance control tests installed at his plant to the complete satisfaction of the Engineer. The test facilities and their operation shall be open to inspection by the Engineer on demand.

All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipment and labour shall be borne by the manufacturer unless otherwise specified or specially agreed to between the manufacturer and Engineer.

A testing programme shall be submitted by the manufacturer to the Engineer and his approval obtained before commencement of acceptance testing.

Any acceptance testing delayed 180 days beyond the date of production shall require special approval of the Engineer and modified acceptance specification, if deemed necessary by him.

All acceptance testing shall be conducted by the inspector with the aid of the manufacturer's personnel having adequate expertise and experience in rubber testing, working under the supervision of the Inspector and to his complete satisfaction.

Inspection and acceptance shall be carried out lot by lot.

2005.4.1 Acceptance Lot

A lot under acceptance shaft comprise all bearings, including the pair of extra test bearings where applicable, of equal or near equal size produced under identical conditions of manufacture, to be supplied for a particular project.

The size and composition of acceptance lot shall be got approved by the Engineer.

For the purpose of grading levels of acceptance testing, a lot size of 24 or larger number of bearings shall be defined as a 'large lot', while a lot size of less than 24 number of bearings shall be defined as a 'small lot'.

When the number of bearings of equal or near equal size for a single bridge project is large and phased production and acceptance is permitted, the number of bearings supplied in any single phase of supply shall comprise a lot under acceptance. When such phased supply is made, each such lot shall be considered as a large lot for the purpose of acceptance testing.

2005.4.2 Levels of Acceptance Testing

The following two Levels of acceptance testing shall be adopted, depending on lot size:

Acceptance testing Level 1 is a higher level of inspection and testing and shall be applicable to large lots only, unless otherwise specified. This shall involve manufacture of two extra bearings for each lot to be used as test bearings and eventually consumed in destructive testing.

Acceptance testing Level 2 shall be applicable to small lots only, for which one extra bearing shall be manufactured and shall not involve destructive testing of finished bearing. Out of the lot, one bearing shall be selected at random for carrying out material tests. This bearing shall be excluded from the lot accepted.

Acceptance testing Level 1 may be specified for small lots also at the sole discretion of the Engineer taking into account the special importance of a bridge project. The cost of extra bearings, in such cases shall be borne by the user, while the cost of all other materials, equipment and testing shall be borne by manufacturer.

2005.4.3 Testing

Acceptance testing shall comprise general inspection, test on specially moulded test pieces and test on complete bearings or sections for measurement of various quality characteristics detailed below:

2005.4.3.1 Acceptance Testing Level 1

General Inspection

- i) All bearings of the lot shall be visually inspected for absence of any defects in surface finish, shape, hardness or any other discernible superficial defects.
- ii) All bearings of the lot shall be checked for tolerances for overall dimensions, mean bearing thickness, parallelism of bearing surfaces and flatness of load bearing surfaces as specified in Table 2000-3.
- iii) The test shall be carried out on all bearings as part of the standard production process. The temperature of the room in which the bearings are tested shall not vary more than 10 °C. The main objective of this test is to eliminate poorly made bearings by visual inspection in a quick and efficient way. All bearings of the lot shall

be subjected to an axial load to correspond to the design load at serviceability limit state while visual examination is made to check for discernible defects like:

- Misalignment of reinforcing plates
- Poor bond at laminate/steel interface
- Variation in elastomer layer thickness
- Any surface defects developed during testing.

- iv) During acceptance testing, complete test data shall be furnished by the manufacturer and one bearing per lot shall be selected at random and the same test shall be repeated. The bearings shall then be visually inspected for defects and the stiffness shall also be measured.
- v) During the test, the deflection between 30 percent and 100 percent of the maximum load for the application shall be recorded and used to check the consistency of the stiffness value. Variation in stiffness of any individual bearing from the mean of the measured values for all such bearings of the lot, shall not be larger than 20 percent of the mean value.
- vi) In case of any visual defect or unacceptable stiffness during acceptance testing, all bearings of the lot shall be subjected to the same test again and only the bearing that passes the test in all respects, shall be accepted.

Tests on Specially Moulded Test Pieces

- i) Test pieces shall be moulded by the manufacturer with identical compound and under identical vulcanising conditions as used in the manufacture of the bearings of the acceptance lot. The process shall be open to inspection by the Inspector/Engineer.
- ii) Test pieces offered for inspection shall be identified by suitable markings and duly certified by the manufacturer.
- iii) The quality characteristics to be tested are listed below. The specification reference in parenthesis shall define the corresponding

specification for test piece, test method and criterion for acceptance.

Composition (see Note 1 below)

Hardness (Table 2000-1, 1.1)

Tensile strength (Table 2000-1, 1.2)

Elongation at Break (Table 2000-1, 1.3)

Compression Set (Table 2000-1, 2)

Accelerated Ageing (Table 2000-1, 3)

Adhesion Strength (Clause 2005.1.4)

Ozone Resistance (see Note 2 below)

The properties enumerated in Clause 2005.1 and specific gravity of elastomer of test pieces from test bearing, shall be compared with those for corresponding specially moulded test pieces furnished by the manufacturer. The following variations shall be deemed maximum acceptable:

Specific Gravity + 0.2.

Ash Content + 0.5 per cent (e.g., if the ash content of elastomer from test bearing is 4%, the ash content of the specially moulded test piece shall be within 3.5% to 4.5% or vice versa)

Hardness (Table 2000-1, 1.1)

Tensile strength (Table 2000-1, 1.2)

Elongation at Break (Table 2000-1, 1.3)

Compression Set (Table 2000-1, 2)

Accelerated Ageing (Table 2000-1, 3)

Adhesion Strength (Clause 2005.1)

Ozone resistance test can be waived by the Engineer for bearings of CR when satisfactory results of ozone resistance tests on similar grade of elastomer may be available from process control records or development test data furnished by the manufacturer.

Where such process control data are not available or the frequency of testing not deemed adequate, ozone resistance test shall be mandatory for acceptance of bearings of CR.

However, such tests may not be insisted upon for bearings not located in adverse conditions of exposure and where the test on accelerated ageing could be considered as adequate.

Process and acceptance control tests for ozone resistance by an independent testing agency shall be acceptable.

Tests on Complete Bearings or Samples

- i) Two bearings shall be selected at random from the lot as test bearings. The tests to be conducted are:
 - a) Test for determination of shear modulus (on a pair of bearings) and
 - b) Test for determination of compression stiffness (on one bearing out of the selected pair).

The test specifications and acceptance criteria shall conform to those given in Appendix-3 of IRC:83 Part II. The tested bearings shall be part of the lot accepted.

- ii) The test for determination of shear bond strength shall be conducted on two identical bearings selected at random from the lot as test bearings or on two identical specially moulded sample bearings of plan dimension 200 mm x 300 mm and overall thickness 41 mm (3 elastomer layers of thickness 8 mm each, 4 reinforcing plates of thickness 3 mm each, face cover 2.5 mm, and side cover 4 mm) as agreed upon between the manufacturer and buyer:

The test specifications and acceptance criteria shall conform to those given in Appendix-3 of IRC:83 Part II. This is a destructive test and the test bearings shall not be used in the structure.

2005.4.3.2 Acceptance Testing Level 2

General Inspection: This shall conform to the provisions in Clause 2005.4.3.1 in all respects.

Test on specially moulded test pieces: This shall conform to the provisions in Clause 2005.4.3.1 in all respects.

Test on complete bearings: Test for determination of shear modulus shall be conducted using two bearings of the lot selected at random and conforming to relevant provisions of Clause 2005.4.3.1. These bearings shall, however, be part of the lot accepted. The remaining tests stipulated in aforesaid clause shall be carried out on two bearings selected at random which shall be excluded from the lot accepted.

2005.4.4 Special Acceptance Inspection

Special acceptance inspection shall comprise the following:

- i) Acceptance testing by a NABL accredited independent external agency with separate or supplemental test facilities provided by it for polymer identification and confirmation about percentage of polymer content and ash content by TGA method.
- ii) Acceptance testing on test pieces prepared from the surface or body of the test bearings instead of specially moulded test pieces.
- iii) Acceptance testing on cut sample from finished bearing in order to measure thickness of individual layer of elastomer, dimension of laminates and flatness of laminates.
- iv) Acceptance test at ULS condition. Bearings tested at ULS condition cannot be used in the structure as its performance at SLS condition cannot be guaranteed after such test.
- v) Acceptance tests not covered by these specifications but according to the specifications laid down by the Engineer.

Special acceptance inspection may be specified under the following conditions:

- a) Special contract agreement between the manufacturer and the buyer. Cost of additional bearings to be consumed for special acceptance inspection, shall be borne by buyer.
- b) Evidence of unsatisfactory process or acceptance control

2005.4.5 Inspection Certificate

A lot under inspection shall be accepted by the Inspector and so certified, when no defect is found with respect to any of the quality characteristics tested on samples drawn from the lot, according to specifications laid down to Clause 2005.4.3 covering general inspection tests on specially moulded test pieces and on complete bearings.

In case any bearing is found defective, the lot shall be rejected by the Inspector and so certified.

In case any bearing is found to be defective with respect to any quality characteristic, discerned by general inspection tests specified in Clauses 2005.4.3.1 and 2005.4.3.2, tests on specially moulded test pieces and complete bearings as applicable according to those Clauses, shall nevertheless be completed. If the said lot, rejected by general inspection, satisfies the acceptance criteria in respect of these other tests, the lot and individual bearings found defective shall be clearly identified in the inspection certificate.

Immediately on completion of inspection by the Inspector authorized by the Engineer, the manufacturer shall obtain an inspection certificate which shall include the details of a lot or lots accepted/rejected by him and records of all test measurements.

2005.4.6 Quality Control Certificate

The manufacturer shall certify for each lot of bearings under acceptance that:

- a) an adequate system of continuous quality control was operated in his plant.
- b) the entire process remained in control during the production of the lot of bearings under acceptance, as verified from the quality control records/charts which shall be open to inspection of Engineer/Inspector on demand.

A certified copy of results of process control testing done on samples of elastomer used in the production of the lot shall be appended and shall include the following information:

Composition of compound — raw elastomer and ash content, the grade of raw elastomer used (including name, source, age on shelf), test results of hardness, tensile strength, elongation at break, compression set, accelerated ageing, etc.

A higher level certification of the process quality control shall be called for at the sole discretion of the Engineer in special cases e.g. where adequate inspection of bearings similar to those comprising the lot under inspection produced in the same plant, is not available with the Engineer or where there is any evidence of process or acceptance control being deemed unsatisfactory. The higher-level certification shall comprise submittal of a complete quality control report covering tests as given in Appendix 3 of IRC:83 (Part II), supplementing the quality control certificate.

2005.4.7 Acceptance

The manufacturer shall furnish the following to Engineer for obtaining acceptance:

Quality control certificate as laid down in Clause 2005.4.6.

Inspection certificate as laid down in Clause 2005.4.5.

The manufacturer shall furnish any supplementary information on the system of quality control and/or process and acceptance control testing as may be deemed necessary by the Engineer.

In case of any evidence of process or acceptance control testing being deemed unsatisfactory by him, Engineer at his sole discretion may call for a special acceptance testing of the lot according to specifications laid down by him, without any prejudice to his right to reject the lot. The entire cost of such supplementary inspection shall be borne by the manufacturer.

The Engineer shall be the sole authority for acceptance of a lot on scrutiny of the certificates along with any supplementary evidence as mentioned in this Clause, to his complete satisfaction therewith.

In case of rejection of a lot, the Engineer shall reserve the right to call for special acceptance inspection for the succeeding lots offered for inspection, according to the specifications laid down by him. The entire cost of such tightened inspection shall be borne by the manufacturer.

2005.5 Certification and Marking

Bearings shall be transported to bridge site after final acceptance by Engineer and along with an authenticated copy of the certificate to that effect.

Each bearing shall be uniquely and individually numbered on its external faces for identification. The identification number shall be unique and such as to enable other bearings manufactured at the same time, to be traced through the production control records, should the need arise. The manufacturer's name and unique identification number of the bearing should be vulcanized on the top or bottom of the bearing.

An information card giving the following details for the bearings, duly certified by the manufacturer, shall also be appended:

- Name of manufacturer
- Date of manufacture
- Elastomer grade used
- Bearing dimensions
- Production batch no.
- Acceptance lot no.
- Date of testing
- Name and specific location of bridge
- Explanation of markings used on the bearing

All bearings shall have suitable index markings identifying the information. The markings shall be made in indelible ink or flexible paint and if practicable, should be visible after installation. The top of the bearing and direction of installation shall be indicated.

2005.6 Storage and Handling

Each elastomeric bearing shall be clearly labelled or marked. The bearing shall be wrapped in a cover and packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges.

Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather of the bearings during transport and handling prior to and during installation.

2005.7 Installation

- i) Bearings shall be installed in the structure as specified or approved by the Engineer to ensure that right bearing is being installed at the right location.
- ii) Bearings must be placed between true horizontal surfaces (maximum tolerance 0.2 percent perpendicular to the load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance ± 3 mm).
- iii) Concrete surfaces shall be free from local irregularities (maximum tolerance ± 1 mm in height).
- iv) Departures from common planarity of twin or multiple bearings shall be within such tolerance as may be specified or approved by the engineer.
- v) Design shall be got checked for the actual inclination in seating if larger inaccuracies than those specified are permitted.
- vi) For cast in-situ concrete superstructure, where bearings are installed prior to concreting, the forms around the bearings shall be capable of easy removal. Forms shall also fit the bearings snugly and prevent any leakage of mortar/grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.
- vii) Fixing of bearing to precast concrete or steel superstructure elements, shall be done by application of epoxy resin adhesive to interface, after specified surface preparation. The specifications for adhesive material, workmanship and control

shall be approved by the Engineer. Care shall be taken to guard against faulty application and consequent possibility of behavior of the adhesive layer as a lubricant. The bonding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearings against displacement for the purpose of design.

- viii) Lifting of a cast in-situ post-tensioned bridge deck for relieving time dependent deformation shortly after installation of bearings, should be avoided. In case such lifting is unavoidable, the lifting arrangement, proper seating of the girder on the bearing, etc. shall be rigidly controlled to avoid any risk of misalignment.
- ix) Bulging of the rubber layer between the reinforcing steel laminates on free exposed perimeter under load, which is a normal phenomenon, shall be examined carefully for detecting any evidence of crack or bond failure.
- x) In case seating of bearings on a non-horizontal plane is required, it shall be carried out in accordance with acceptable practice and particular specifications as may be laid out and directed by the Engineer.
- xi) As a measure of ample precaution against accidental displacement, the bearings shall be placed in a recess as shown in Fig. 9 of IRC:83 (Part II).
- xii) After installation, bearings and their surrounding areas shall be left clean.

2005.8 Maintenance

- i) The maintenance of bearings shall be carried out according to a planned schedule.
- ii) The structure should be designed and detailed in such a way that the bearings are easily accessible after installation for inspection and maintenance. Arrangements for insertion of

jacks to lift the bridge deck shall be made in detailing of structure.

- iii) The exposed bearing surface shall be maintained clean and free from contamination with grease, oil or other deleterious matter.
- iv) Annual routine maintenance inspection or special maintenance inspection of all bearings shall be made to check the following aspects and results reported:
 - The top and bottom load bearing surfaces shall be in full contact with the plinth (bottom supporting surface) and the soffit (top supporting surface). If there is imperfect contact between the bearing surfaces and the soffit and plinth, the angle between the soffit and plinth shall be checked against the design specifications.
 - The magnitude of the shear deflection of each bearing shall be checked to ensure that it is within the design specifications.
 - A visual inspection shall be made of all the accessible edges. A note shall be made of the size and position of any cracks, splits or uneven bulges.
 - The plinth and soffit shall be examined for signs of displacement from original position of bearing which may be indicated by black marks left on the plinth and soffit.
 - Where applicable, the sliding surfaces shall be examined for cleanliness and for any movements beyond the design range.
 - Where applicable, protective coating and/or dust protection shall be examined for signs of deterioration.
- v) Damaged bearings shall be replaced immediately. To avoid differences

in stiffness, all adjacent bearings on the same line of support shall also be replaced.

2006 POT BEARINGS

2006.1 General

Pot bearings shall consist of a metal piston supported by a disc of unreinforced elastomer confined within a metal cylinder to take care of rotation. Horizontal movement, if required,

2006.6 Maintenance

- i) Bearings shall be designed and manufactured to make them maintenance free so as to withstand undesirable effects caused by extreme atmosphere or aggressive environmental conditions/ unforeseen events.
- ii) Suitable easy access to the bearings shall be provided for inspection and maintenance. Provision shall also be available for jacking up the superstructure so as to allow repair/replacement of bearings.
- iii) The area surrounding the bearings shall be kept clean and dry to avoid damage to the bearings. The bearings shall also be periodically cleaned to remove deposits of salts, debris, dust or other foreign material.
- iv) Periodic inspection and nominal maintenance of bearings shall be carried out in order to ensure their better performance and longer life. The bearings are required to be inspected at intervals of one year for the first five years after installation and at intervals of two years thereafter.
- v) The bearings shall also be examined carefully after unusual occurrences such as passage of heavy traffic/oversized loads, earthquakes and battering by floating debris in high floods.

2007 INSPECTION AND TESTING

Where any patented items are used, the manufacturer's certificate for the same with test proofs shall be submitted along with the design and got approved by the Engineer before their use in work.

2008 TEST AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

2009 MEASUREMENTS FOR PAYMENT

Bearings shall be measured in numbers, according to their capacities and particular specifications given on the drawings.

The quantity of elastomeric bearings shall be measured in **cubic centimeters** of finished dimensions.

2010 RATE

The contract unit rate of each type of bearing shall include the cost of manufacturing, supplying and fixing the bearings in position complete as specified on the drawings or as directed by the Engineer.

The rate shall also include the cost of samples and their testing as required under the specifications or as directed by the Engineer.

In case of steel bearings, the rate shall include the cost of all nuts, bolts and all tests prescribed in the specifications and shown on the drawings.

Formwork, concrete and reinforcement for piers shall conform to relevant sections of these specifications. In case of concrete piers, the number of horizontal construction joints shall be kept minimum. Construction joints shall be avoided in splash zones unless specifically permitted by the Engineer and provided they are treated in accordance with special provisions. No vertical construction joint shall be provided. The work shall conform strictly to the drawings or as directed by the Engineer.

In case of tall piers use of slip form shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which will be furnished by the Contractor. The concrete shall also be subject to additional specifications as necessary. All specifications and arrangements shall be subject to the approval of the Engineer.

The surface of foundation shall be scrapped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

Item No.22:- Providing and fixing metal modular strip seal expansion joints as per drawings. Details of expansion joint 50 x 50 x 6mm size two IS and 100 x 6mm MS plate with 6 x 20 x 25mm long hold fast @ 50 cm / cc on both sides of expansion joints.

2601 DESCRIPTION

The work shall consist of fabrication and installation of expansion joints. The filler joint, asphaltic plug joint, compression seal joint and reinforced elastomeric joint of slab seal, strip seal and box seal type shall conform to these Specifications.

2602 GENERAL

2602.1 The type of expansion joint proposed to be used shall conform to the design and got approved by the Engineer.

2602.2 Expansion joints shall be robust, durable, water-tight and easy for inspection, maintenance and replacement. Site fabricated expansion joints shall be prohibited. Expansion joints shall be procured from approved manufacturers and shall be of proven type.

2602.3 Alternative proprietary type deck joints proposed by the Contractor in lieu of the type specified shall comply in all respects with the manufacturer's specifications and meet the required range of movements and rotations and be fit for the purpose of ensuring satisfactory long term performance. For such proprietary type deck joints the following information shall be provided.

- i) Name and location of the proposed manufacturer.
- ii) Dimensions and general details of the joint including material specifications, holding down bolt or anchorage details and installation procedures.
- iii) Evidence of satisfactory performance under similar environmental conditions of similar joints being produced by the manufacturer.

Acceptance of any alternative type of expansion joint shall be at the sole discretion of the Engineer. Such deck joints shall be installed in accordance with the manufacturer's recommendations and to the requirements of these Specifications. Vehicular traffic shall not be allowed over expansion joints after their installation for such period as may be determined by the Engineer.

2602.4 The expansion joint shall be provided to cover the entire carriageway, kerb and footpath, wherever provided. It shall follow the profile of the deck including the kerb, footway and fascia. The expansion joint for kerb, footway and fascia may be of different type and specification from that used for the carriageway and it shall cater to all movements and rotations for which the carriageway expansion joint is designed and shall be water tight.

2603 PERFORMANCE REQUIREMENTS

2603.1 The expansion joint proper and the transition zone (the zone of connection of joint assembly and the adjoining deck) shall satisfy the performance requirements specified herein. The expansion joint proper shall satisfy the performance requirements of both the bridge structure and the road users.

2603.2 Performance Requirements with Respect to Bridge Structure

The expansion joint shall:

- i) withstand the imposed loads including the impact load from live load and other sources,
- ii) allow expansion and contraction movement due to temperature, creep, shrinkage, pre-stressing and structural deformations,
- iii) permit relative rotation in elevation and plan due to the causes mentioned above,
- iv) be waterproof,
- v) be properly sealed,
- vi) ensure long life by being resistant to corrosion,
- vii) be easy to install,
- viii) be easy to maintain.
- ix) be easy to replace. and
- x) be resistant to the materials likely to collect/spill over the deck in its normal service.

2603.3 Performance Requirements with Respect to User

The expansion joint shall:

- i) provide smooth continuity at the top of the deck for riding comfort,
- ii) be skid resistant,
- iii) be non-damaging to rubber tyres,
- iv) make little or no noise during passage of vehicles,
- v) ensure that animal paws and hooves do not get entangled when used by animal drawn traffic,
- vi) permit passage of steel tyre of bullock carts without being damaged, and
- vii) look good aesthetically.

2606.1. Components

Strip seal expansion joint shall comprise the following items:

- i) Edge beams - This special claw leg profiled member shall be of extruded rolled steel section combining good weldability with notch toughness.
- ii) Strip seal - This shall be of chloroprene with high tear strength, insensitive to oil, gasoline, and ozone. It shall have high resistance to aging. This component, provided to ensure water tightness, shall have bulbous shape of the pan of the seal which is inserted into the groove, provided in the edge beam. The seal should be vulcanized in single operation for minimum full length of joint.
- iii) Rigid Anchorage - This shall be welded to the edge beam at staggered distance.
- iv) Anchor loops - This shall be made of weld able steel connecting the rigid anchorage with, deck reinforcement

2606.2. Material

- a) Edge beams of this special section are at present being directly imported in India. The steel shall conform to steel grade Rst 37-2 of German Standard or equivalent.

- b) Chloroprene of strip seal shall conform to clause 915.1 of RC:83 (Pan II). The properties of chloroprene shall conform to Table 2600-1
- c) Anchorage steel shall conform to IS:2061
- d) Anchor loop shall conform to IS:2062.

TABLE 2600-1. STRIP SEAL ELEMENT SPECIFICATION

Scaling element is made of chloroprene and must be a extruded section. The working movement range of the sealing element shall be at least 80 mm with a maximum of 100 mm at right angles to the joint and ± 40 mm parallel to the joint

PROPERTY	SPECIFIED VALUE
Hardness	63 \pm 5 Shore A
Tensile Strength	Min 11 MPa
Elongation at fracture	Min 350 per cent
Tear Propagation Strength	
Longitudinal	Min 10 N/mm
Transverse	Min 10 N/mm
Shock Elasticity	Min 25 per cent
Abrasion	Min 220 mm ³
Residual Compressive Strain (22 h/70 deg C/30 per cent strain)	Max 28 per cent
Ageing in hot air (14 days/70 deg C)	Max +5 Shore A
Change in hardness	Max -20 per cent
Change in tensile strength	Max -20 per cent
Change in elongation at fracture	
Ageing in ozone (24 h/50pphm/25 deg C/20 per cent strain)	No cracks
Swelling behavior in Oil (116 h/25 per cent Q ASTM Oil no.	
	Max 5 per cent
Volume Change	Max 10 Shore A
Change in hardness	
ASTM Oil no.3	Max 25 per cent
Volume Change	Max 20 Shore A
Change in hardness	Min -35 deg C
Cold Hardening Point	

2606.3. Fabrication (Pre-installation)

- a) Rolled steel profiles for edge beams shall be long enough to cater for a 2-lane carriageway. These shall be cut to size of actual requirements by means of a meter box saw. Alignment of the cut-to-size steel profiles shall then be made in accordance with the actual bridge cross-section on work tablet. For this purpose, the contour of bridge cross-section shall be sketched onto these tables. After the

steel profiles are aligned, they will be chucked to the tables by means of screw clamps and tacked by arc welding.

b) Anchor plates shall be cut to the required size by gas cutting. These shall be welded to the edge beams.

c) Anchor loops shall be bent to the required shape and welded to anchor plates.

d) The finally assembled joints shall then be clamped and transported to the work site.

2606.4. Handling and Storage

a) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.

b) The manufacturer shall supply either directly to the Engineer or to the Bridge Contractor all the materials of strip seal joints including sealants and all other accessories for the effective installation of the jointing.

c) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding by the Contractor to prevent damage. Any damage occurring after delivery shall be made good at the Bridge Contractor's expense to the satisfaction of the Engineer.

2607 MODULAR STRIP/BOX SEAL EXPANSION JOINTS

2607.1 Components

A modular expansion joint shall consist of two or more modules/cells of individual capacity 80 mm to cater to a horizontal movement in excess of 80 mm. It shall allow movements in all three directions and rotation about all three axes as per the design requirements. The structural system shall consist of two edge beams, one or more central/separation beams or lamellas and cross support bars supporting individuals or multiple central beams to transfer the loads to the bridge deck through the anchorage system.

Edge Beams and Central Beams/Lamella : These shall be as per Clause 2606.1(i).

Anchorage : Anchorage of edge beam shall be as per Clause 2606.1 (ii). Studs and/or loop anchors with anchor plate may be used as anchorage of other components like joist box and covers of controlling system.

Sealing Element : This shall be as per Clause 2606.1 (iii). Minimum gap for inserting the neoprene seals in the expansion joint shall be 25 mm.

Support and Control System : The control system should allow closing and opening of the joint and also ensure that all modules open and close equally during all movement cycles of the joint. The overall support and control system shall be either single/multiple support bar control system or swivel joint system comprising of resilient/shock absorption components and elastic/sliding control system conforming to the specifications recommended by the manufacturer. The gap between the consecutive center beams at the joint surface shall be limited to 80 mm when the joint opens fully due to maximum contraction of deck.

2607.2. Material

i) The steel for edge beams, center beam/lamella, transverse support bar and other steel components shall conform to any of the steel grade corresponding to RST 37-2 or 37-3 or 52-3 (DIN), S235JRG2 or S355K2G3 of EN10025 (DIN 17100), ASTM A36 or A588, CAN/CSA standard G40.21 Grade 300 W.

ii) The sealing element shall be of Chloroprene Rubber (CR). The properties of CR shall be as specified in Table 2600-1.

- iii) The specification for all other materials shall be as per manufacturer's recommendation.

2607.3 Fabrication (Pre-installation)

- i) Profile of edge beam, center beam/lamella shall be long enough to cater for full carriageway width.
- ii) The fabrication of all components of the joints including anchorage system and transportation of assembled joints shall be as per manufacturer's specification.
- iii) **Lubricant cum Adhesive :** The type and application of material used in bonding the preformed joint seal to the steel nosing and concrete shall be as recommended by the manufacturer/supplier of the seal system.
- iv) **Corrosion Protection :** All steel sections shall be suitably protected against corrosion as stated in Clause 2606.3 (iv).

2607.4 HANDLING AND STORAGE

- i) Arrangement for transportation and storage shall be as per manufacture's Specification.
- ii) The manufacturer shall supply either directly to the engineer or to the bridge contractor all the materials of strip seal joints including sealants and all other accessories for the effective installation of the joining.

2610 INSTALLATION OF EXPANSION JOINTS

2610.1 General Procedure

- i) Expansion Joints shall be installed under close supervision of the manufacturer's/supplier's engineer in order to ensure the quality of installation and its function as intended during the entire life span. Detailed Installation Manual shall be supplied by the manufacturer/supplier.
- ii) The dimensions of the recess in the deck shall be established in accordance with the drawings or design data of the manufacturer, taking into account the width of gap for movement of the joint.
- iii) The pre-setting of expansion joint shall be done by means of an auxiliary construction.
- iv) The road surfacing/wearing coat shall be laid before commencing installation of joint. Before laying wearing coat, the recess portion shall be filled with sand and wearing coat shall be laid in a continuous manner over the deck slabs and recess portion. Prior to installation of the joints, portion of wearing coat over the recess shall be removed by a suitable method e.g. saw cutting and the infill sand shall also be removed.
- v) **Preparation of the Recess :** The size and form of recess shall suit the geometry of the expansion joint. However, the width shall not be less than the specified value for a particular type of joint. In order to avoid difficulties during installation, the following points must be checked and considered:
 - a) Dimension of recess
 - b) Levels
 - c) Skew and slope

- d) Designed gap between bridge deck and abutment and/or between adjoining decks
- e) Existing structural reinforcement according to the drawings

Reinforcing bars that would obstruct the installation of expansion joint shall be bent to accommodate the expansion joint anchorages. Cutting off or removal of interfering reinforcing bars shall only be done after consultation with the Engineer.

The recess shall be cleaned thoroughly. If necessary, the surface should be roughened. All loose dirt and debris shall be removed by wire brushing, air blowing and dried with hot compressed air.

- vi) **Shuttering** : Shuttering must be used to seal the space between the underside of the joint and the vertical face of the recess. The shuttering must be fitted in such a way that it forms an appropriate seal against the edge of the recess. The recess shall be shuttered in such a way that dimensions shown on the drawing are maintained. The formwork shall be rigid and firm.
- vii) **Placing in the Recess** : Level marks shall be set next to the recess. This enables a controlled leveling of the expansion joint. Lowering the expansion joint/joint construction/insert into the recess shall be done in such a way that the entire length of the joint is evenly lowered into the recess. Thereafter, the joint/joint construction/insert is precisely leveled and adjusted in the longitudinal, transverse and vertical planes. If required, the joint must also be adjusted to the gradient of the final surface level.
- viii) **Connection**
 - a) The expansion joint/joint construction/insert shall be installed preferably in the early morning when the temperature is distributed almost uniformly over the whole bridge. Immediately before the installation, the actual temperature of the bridge shall be measured. If it is not within the considered tolerance, the pre Set adjustment shall be corrected. The joint/joint construction/insert shall be lowered in a predetermined position. Following placement of the joint/joint construction/insert in the prepared recess, the joint/joint construction/insert shall be leveled and finally aligned and the anchorage steel on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side. With the expansion joint/joint construction/ insert finally held at both sides, the auxiliary brackets shall be released, allowing it to take up the movement of the structure. After carrying out the final fixing, the protection against corrosion shall be completed.
 - b) For fully assembled joints with one end fixed and other end movable e.g. modular strip/box seal joint, connection shall be as detailed below:

The 1st side : The fixed side of the assembled joint (either the abutment or the bridge deck side) is designated the 1st side for connecting the joint. The preliminary fixing is made by evenly placing and welding of reinforcing bars over the entire length between the anchor loops and the deck reinforcement. To facilitate concreting, the gap between recess and shuttering is sealed by a grout seam. The seam must be left to dry prior to final concreting. After this, additional reinforcing bars are welded until all anchor loops are firmly connected to the deck reinforcement. The expansion joint shall be considered sufficiently fixed when no vibration is noted when it is lightly tapped. The expansion joint shall not be subjected to any loads that could in any way displace the precise location of this fixing.

The 2nd side : Depending on the size of the expansion joint and the expected movement during installation, the most suitable time must be determined for fixing of the 2nd (moveable) side. Usually this is the early morning hours with the smallest temperature deviations. The procedure is identical to that for the 1st side. The joint shall be provisionally fixed to the reinforcement as fast as possible. Immediately afterwards, the fixation brackets shall be removed. Thereafter, the gap between recess and shuttering shall be sealed with grout seam and the remaining reinforcing bars welded as described previously.

ix) **Concreting**

a) Prior to final concreting, the position of the joint/joint construction/ insert must be recorded. The Engineer must give written confirmation of the correct position of the joint and recess concreting. The recess shall be thoroughly watered. Before pouring the concrete the joint construction should be protected by a cover. Controlled concrete having strength not less than that in superstructure subject to a minimum of M35, shall be filled into the recess. The water cement ratio shall not be more than 0.4. If necessary, admixtures may be used to improve workability. The concrete must exhibit low shrinkage. The freshly placed concrete shall be properly vibrated. Damage to the shuttering shall be avoided during vibration. The concrete shall be finished flush with the carriageway surfacing. The concrete shall be kept damp until it has cured in order to avoid fissures caused by drying too fast. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

b) For modular strip seal joint the space beneath the joint boxes shall be completely filled with concrete. So that traffic loads are safely transmitted into the structure.

x) As soon as the concrete in the recess has become initially set, a sturdy ramp shall be placed over the joint to protect it from traffic at site.

Expansion joint shall not be exposed to traffic loading before completion of carriageway surfacing.

xi) The elastomeric sealing element may be field installed. For strip seal and modular strip seal joints the sealing element shall be in

continuous lengths spanning the full carriageway width. Proper fit of the seal of the sealing element must be ensured. The seal shall be installed by suitable methods in such a way that it is not damaged.

2610.5 Specific procedure for Modular Strip/Box Seal Joint

- a) The procedure given Clause 2610.4 (i) and (ii) applies to modular strip/box seal joint also.
- b) To ensure proper fit of the seal, dirt, spatter or standing water shall be removed from the steel cavity using a brush, scraper or compressed air.
- c) The actual junction of the surfacing/wearing coat with the block out concrete/steel edge section shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

2610.6 Specific Procedure for Reinforced Elastomeric Joint

Expansion joints shall be installed as per approved drawing. The procedure for installation of various components shall be as follows:

i) Steel Inserts

- a) Deck casting shall be done leaving pockets or recesses for steel inserts and anchors of the expansion joint as per drawing.
- b) Steel inserts shall be lowered at the appropriate location inside the pocket.
- c) The top of the insert shall be flush with the finished level of wearing course maintaining the camber.
- d) Spacer bars, duly set appropriately to the month of installation, shall be fitted under proper supervision.
- e) Anchor rods shall be tied/welded with the existing deck main reinforcement, maintaining level and alignment.
- f) Welding between anchor rods and deck reinforcement is preferable. If welding is not possible, strong steel tie wires shall be used for fastening under proper supervision.

ii) Spacer Bar

- a) Spacer bars shall be used to ensure proper positioning of bolts and also leveling of the steel inserts during fixing of the same with the deck reinforcement and casting second stage concreting in the pocket thereafter.
- b) The 2nd stage concreting operation shall preferably be started within 24 hours of fixing the steel inserts. In such cases, spacer bars should be removed just after concreting is finished. If there is a substantial time lag between fixing of inserts and concreting, then any one of the following

methods shall be adopted, depending on the support condition:

For simply supported bridge resting on simple elastomeric bearings, (with no dowel pins), insert shall be placed in position with spacer bars at every alternate joints. Such joints shall be called restrained joints hereafter. In other words, inserts shall not be fixed simultaneously at two ends of one span. If the above condition is satisfied, inserts with spacer bars shall be kept in position for a substantially longer period at such restrained joints. Spacer bars shall be removed after concreting of such restrained joints and inserts placed in position with spacer bars at the other unrestrained joints thereafter.

For bridges resting on other than elastomeric bearings (including bearings with dowel pins at one end), after placing and aligning the inserts and securing the same, the spacer bars shall be removed. Concreting shall be done with great care so that inserts are not dislocated or distorted.

- c) While removing the spacer bar after concreting, one must take care to see that the concrete is not damaged during withdrawal of spacer bar. If the spacer bar happens to be snugly fitted, it shall not be pulled by any means; it shall be gas cut in two pieces and then removed.

iii) Concreting of Pocket

- a) Concreting of pocket shall be done with great care using proper mix conforming to grade similar to that of the deck casting besides ensuring efficient bonding between deck and steel insert. Also proper care shall be given for ensuring efficient bonding with the already cast concrete. Requirement of concrete as per Clause 2610.9.1 shall be followed.
- b) Needle vibrators shall be used. Care shall be taken so that the position of steel insert is not disturbed during vibration.
- c) Spacer bar shall be removed within an appropriate time before the joint is required to permit movement.

iv) Fixing of Elastomeric Slab Unit (ESU)

- a) Special jig shall be used to preset the ESU during installation
- b) ESU (mounted on the jig, if preset) shall be lowered to position.
- c) The line and level on the ESU should be adjusted.
- d) ESU shall be removed and coated with special adhesive
- e) ESU shall be placed in position again, ensuring waterproof joining at required faces.
- f) ESU shall be tightened with stainless steel nuts and lock washers in position. Tightened nuts shall be locked with lock washers.
- g) Special sealant shall be poured inside the plug holes.
- h) The elastomeric plugs shall be pressed in position after applying adhesive on the appropriate surface.

- i) ESU shall be fitted in position after completion of wearing course. While completing this part of the wearing course, adequate care shall be taken to ensure a waterproof joining with the already existing wearing course.

v) Pre-setting

- a) The main purpose of pre-setting of the steel inserts at the time of its installation is to ensure as closely as possible the condition that in the long run at the mean average annual temperature, the ESU remains at its nominal state.
The steel insert unit of expansion joint can be fixed in any month of the year. The expansion gap between bridge super structures may vary from time to time; hence the initial fixing distance between fixing points will obviously depend on the month of installation of steel insert. The c/c distance between stainless steel fixing of bolts as indicated in the drawing can be taken as only nominal. The same shall be modified by pre-setting depending on:
The difference between the mean temperature of the month of fixing of steel insert and the annual average temperature, and
The elapsed period between the casting and/or pre-stressing and fixing of steel insert for calculating the remnant creep and shrinkage.

vi) Special Requirements for Installation

- i) The supplier shall provide detailed working drawings showing the location of all bolts, recesses and holes necessary for the installation of the joint shall be obtained from the supplier before construction of bridge deck area adjacent to the joint. If required detailing of reinforcing bars in superstructure shall be modified to ensure that there will be no interference in the installation of the joint.
- ii) All bearing surfaces and recesses which are in contact with the joint assembly shall be checked with a straight edge to ensure flatness of profile.
- iii) No holes shall be drilled for fixing bolts within 7 days of concreting. Holes for the bolts shall be drilled to the size and depth shown on the drawings.
- iv) Sections of the jointing making the completed joint shall follow a straight line.
- v) The fixing bolts shall not be placed in a position until at least 4 weeks after stressing is completed in post-tensioned box or beam and slab structures. Prior to placing sections of jointing, contact surfaces shall be cleaned to remove all grease, tar, paint, oil, mud or any other foreign material that may affect adhesion of the sealant.
- vi) Sealant shall only be applied to dry contact surfaces. Sufficient

- quantity shall be applied to the contact surfaces so that sealant is extruded when the jointing is fixed in position.
- vii) Final sealing of the finished expansion joint shall be completed immediately after installation. All exposed ends, joints between units, other areas of possible leakage, voids between the sides of the jointing and concrete or plates, shall be filled with sealant.
 - viii) Bolt cavities shall be cleaned and plugged with neoprene cavity plugs. Prior to placing the plugs sufficient sealant shall be placed in the cavities to cause extrusion of the sealant by the plugs.
 - ix) All excess sealant shall be removed from the jointing and adjacent areas.

2611 Procedure for installation of various joints, shall also take into account suppliers own specific procedures for installation of each type of joint as the suppliers shall be responsible for performance of the joints for the period of guarantee.

2612 TESTING AND ACCEPTANCE STANDARDS

2612.1 Before installing joints in a bridge, sufficient evidence of the reliability of the proprietary products shall be furnished. A copy of the fatigue and wear test reports, as applicable depending upon the type of joint, carried out by a recognized laboratory/university/ institute on the joint components as a part of product development test, shall be furnished once for the entire lot of supply. The tests covered in Clauses 2612.1. 0) to 2612.1. (vi) need not be carried out on the materials of the joints of supply lot but shall be carried out from time to time by the original manufacturer as per their product development and quality plan for the same type of joints to ensure the performance requirement of the particular joint component against fatigue and/or wear.

- i) For single strip seal and modular strip seal joints, the manufacturer shall produce complete report of the test of anchorage system from a recognized laboratory to determine optimum configuration of anchorage assembly under dynamic loading in support of the efficacy of the anchorage system adopted for the entire lot of joints.
- ii) For modular strip seal joints the manufacturer shall produce a test report from a recognized laboratory that the sliding bearings (suspension system) have been fatigue tested for six million load cycles with a frequency of 5 Hz and the loads of 80 kN, 120 kN and 160 kN.
- iii) For modular strip seal joints the manufacturer shall produce a test report from a recognized laboratory that the wearing of sliding interface of bearings of modular joints has been tested for a total sliding distance of 5000 m at a load of 48 kN.
- iv) For modular strip seal joints the manufacturer shall also produce a test report from a recognized laboratory that the

sliding material of sliding springs of expansion joints has been tested for a total sliding distance of 20,000 m with a load equivalent to a stress of 30 MPa.

- v) For modular strip seal joints the manufacturer shall also produce a test report from a recognised laboratory that the butt-welded splicing of centre beams has been tested with two million load cycles with a load equivalent to a stress of 165 MPa.
- vi) In case of reinforced elastomeric joints abrasion resistance test shall be carried out in accordance with IS:3400 (Part 3) or DIN 53516.

2612.2 Pre-installation Criteria

The pre-installation criteria shall include the routine tests and acceptance tests as described below:

2612.2.1 Routine Tests

Routine tests including tests for materials conforming to specifications shall be carried out by the original manufacturer i.e., in case of imported joints, by the foreign manufacturer as part of their quality control procedure for all joints to be supplied by them. Detailed documentation of all the tests and inspection data as per complete quality control procedure shall be supplied by the original manufacturer in the form of Quality Control Report. Routine tests shall include:

Raw materials inspection, Process inspection, and Complete dimensional check as per approved drawings.

- i) **Raw Material Inspection** : Test on all raw materials used for the manufacturing of joints as per relevant material standard based on these Specifications shall be carried out by the manufacturer.
 - a. **Confirmation of the Grade of Steel** : Grade of the steel for the edge beam shall be confirmed by conducting tests for yield stress, tensile strength and elongation. Corresponding to RST 37-2 or 37-3 or 52-3 (DIN), 5235 JRG2 or S355K2G3 of EN10025 (DIN 17100), ASTM A36 or A 588, CAN/CSA standard G 40.21 grade 300 W or equivalent to Grade B of IS: 2062. The manufacturers/ suppliers shall have in-house testing facilities for conducting these tests.
 - b. Tests for steel for the anchorage shall conform to IS:2062.
 - c. The tests as indicated in Table 2600-1 shall be made for checking the following properties of the chloroprene seal: (a) hardness, (b) tensile strength, (c) elongation at fracture, (d) tear propagation strength, (e) residual compressive strain, (f) change in hardness, (g) change in tensile strength, (h) change in elongation at fracture, (I) ageing in ozone, and (j) swelling behaviour in oil. The manufacturers/suppliers shall have in-house testing facilities for conducting these tests.
- ii) **Process Inspection** : Process inspection including inspection of all manufacturing processes adopted to manufacture the joints e.g., welding, corrosion protection, clamping, pre-setting, greasing, bonding by adhesives and riveting, as appropriate, shall be carried out by the manufacturer.

- iii) **Complete Dimensional Check** : Complete dimensional check of all components of joint as well as the assembled joint with respect to the approved drawings and tolerances as per these Specifications, shall be carried out by the manufacturer.

2612.3 Acceptance Tests

2612.3.1 In addition to the tests specified under Clause 2612.1, the manufacturer as well as the local supplier in case of imported joints shall have complete in-house testing facilities for the following tests. The Engineer shall insist upon these tests before acceptance of the joint.

- i) **Cyclic Motion** : Cyclic motion test may be carried out once on one complete joint assembly or one meter sample piece selected at random from the entire lot of supply for each type of joint irrespective of movement capacity. The test sample shall be subjected to 5000 expansion and contraction cycles at minimum 30 cycles per hour. The test movement shall be 10 percent more than the design expansion/ contraction movement. Any sign of distress or permanent set of any component or the assembly due to fatigue, will lead to rejection of entire lot of supply.
- ii) **Ponding** : Prior to acceptance, 25 percent of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25 mm above the highest point of deck. The width of ponding shall be at least 50 mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25 mm anytime during the test. A close inspection of the underside of the joint shall not reveal any leakage.
- iii) **Debris Expelling Test** : Debris expelling test shall be carried out on one metre sample piece selected at random from the entire lot of supply. The fully open gap shall be filled flush with granular debris and cycled 25 times for full opening and closing. The mass of debris expelled after 25 cycles shall be expressed as the percentage of initial mass. The percentage expelled shall not be less than 75.
- iv) **Pull-out Test** : Pull-out test shall be carried out on one meter sample piece selected at random from the entire lot of supply. The joint shall then be stretched until the sealing element slips off from its housing. The minimum stretching of the joint before slip-off shall be least 150 percent of the rated movement capacity of the seal.
- v) **Vehicular Braking/Traction Test** : This is the only initial acceptance (in-house) test. This test may be carried out once on one complete joint assembly or one metre sample piece selected at random from the entire lot of supply for each type of Joint irrespective of movement capacity. The test sample shall be installed between two blocks of concrete in its mean position. A truck wheel load of 40 kN shall be drawn across

the specimen with an engaged ratchet with wheel locked to stimulate locked brakes and then rolled back. The cycle shall be repeated for 50,000 times with a period of 2 seconds. Continuous water cooling will be necessary to control excessive heat generated during the test.

- vi) **Erosion Protection Test** : Adequacy of the treatment for protection of steel sections against corrosion should be checked.

2612.3.2 Applicability of Acceptance Tests on Different Types of Joints

The acceptance tests described in Clause 2612.2.1 shall be applicable as per Table 2600-5 for different types of joints.

Table 2600-5 : Applicability of Acceptance Tests on Different Types of Joints

Performance Evaluation Tests	Asphaltic Plug Joint	Compression Seal Joint	Reinforced Elastomeric Joint	Single Gap Strip/Box Seal Joint	Modular Strip/Box Seal Joint
Cyclic motion	Not Applicable	Applicable	Applicable	Applicable	Applicable
Ponding	Not Applicable	Applicable	Applicable	Applicable	Applicable*
Debris expelling test	Not Applicable	Applicable	Applicable	Applicable	Applicable*
Pull-out test	Not Applicable	Not Applicable	Not Applicable	Applicable	Applicable*
Vehicular braking/traction test	Not Applicable	Not Applicable	Applicable	Applicable	Applicable*

- ❖ For modular strip seal expansion joint ponding test, debris expelling test, pull-out test and vehicular braking/tractor test shall be carried out on one metre edge beam samples only, complete with sealing element and anchorage, to be supplied by manufacturer.

Note: For all expansion joints which are proprietary a minimum guarantee of 10 years for their satisfactory performance shall be given by the contractor.

2613 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

2614 MEASUREMENTS FOR PAYMENT

The expansion joint shall be measured in **meters**.

2615 RATE

In the case of supply and installation contract, the contract unit rate shall include the cost of all material, labour, equipment and other incidental charges for procuring and fixing the joints complete in all respects as per these Specifications. For filler

joints, the rate per **Rmt.** shall include the cost of sealant for the depth provided in the drawing.

In the case of supply contract, the contract unit rate shall include cost of all components of expansion joint including anchorage system, pre-installation fabrication, transportation of assembled joints, handling and other incidental charges. In the case of installation only contract, the contract unit rate shall include the cost of all material, labour, equipment and other incidental charges for installation of the joints complete in all respects as per these Specifications.

Item No.23:- Construction of precast RCC railing of M30 Grade, aggregate size not exceeding 12 mm, true to line and grade, tolerance of vertical RCC post not to exceed 1 in 500, centre to centre spacing between vertical post not to exceed 2000 mm, leaving adequate space between vertical post for expansion, complete as per approved drawings and technical specifications.

This work shall consist of **Construction of precast RCC railing of M30 Grade** and shall be carried out as per relevant detailed specification of **Item No.4** of this contract.

The payment will be made on **Rmt.** basis of the finished work.

Item No.24:- Provision of an Reinforced cement concrete crash barrier at the edges of the road, approaches to bridge structures and medians, constructed with M-40 grade concrete with Fe-550D with fusion bonded epoxy coating with reinforcement conforming to IRC:21 and dowel bars 25 mm dia, 450 mm long at expansion joints filled with pre-moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH - 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the Engineer, all as specified as per drawing attached.(i) cast in situ

This work shall consist of providing and casting in situ-controlled cement concrete M 40 grade for crash barrier shall be carried out as per relevant detailed specification of **Item No.4** of this contract and Steel shall be as per **Item No.16** Grade of concrete will be M-40. All above material shall be used as per complete working drawing and sanctioned by engineer in charge.

The item shall be measured & paid as finished work in **Metre.**

Item No.25:- Providing weep holes in Brick masonry/Plain/ Reinforced concrete abutment, wing wall/ return wall with 100 mm dia PVC pipe, extending through the full width of the structure with slope of 1V:20H towards drawing face Complete as per drawing and Technical Specifications

Weep holes shall be provided in solid plain concrete/reinforced concrete, brick/stone masonry, abutment, wing wall and return walls as show. on the drawing or directed by the Engineer to drive moisture from the back filling. Weep holes shall be provided with 100 mm dia P.V.C. pipe for structures in plain/reinforced concrete or brick masonry. In case of stone masonry, weep holes shall be 80 mm wide, 150 mm high or circular with 150mm diameter. Weep holes shall extend through the full width of concrete/masonry with slope of about 1 vertical:20 horizontal towards the draining face. The spacing of weep holes shall generally be 1m in either direction or as shown in the drawing with the lowest at about 150 mm above the low water level or ground level whichever is higher or as directed by the Engineer.

Weep holes in concrete/brick masonry structure shall be measured in
Nos.

Item No.26:- Providing P.V.C. 100 mm diameter water spouts including necessary iron gratings as per drawings.

This work shall consist of furnishing and fixing in position of drainage spouts and drainage pipes for bridge decks.

2705 Drainage along longitudinal direction shall be ensured by sufficient number of drainage fixtures embedded in the deck slab. The spouts shall be of not less than 100 mm in diameter and shall be corrosive resistant material such as galvanized steel with suitable cleanout fixtures. The spacing of drainage spouts shall not exceed 10 m. The discharge from drainage spout shall be kept away from the deck structure by means of suitable down pipes upto 500 mm above High Flood Level. In case of viaducts in urban areas, the drainage spouts should be connected with suitably located runners and down pipes to discharge the surface run-off to drains provided at ground level.

2705.1. Fabrication

The drainage assembly shall be fabricated to the dimensions shown on the drawings. All materials shall be corrosion resistant; Steel components shall be of mild steel conforming to 18:226. The drainage assembly shall be seam welded for water tightness and then hot-dip galvanized.

2705.2. Placement

The galvanised assembly shall be given two coats of bituminous paint before placement. The whole assembly shall be placed in true position, lines and levels as shown in the drawing with necessary cutouts in the shuttering for deck slab and held in place firmly. Where the reinforcements of the deck are required to be cut, equivalent reinforcements shall be placed at the corners of the cut out.

2705.3. Finishing

After setting of the deck slab concrete, the shrinkage cracks around the assembly shall be sealed with polysulphide sealant or bituminous sealant as per IS: 1834 and the excess sealant trimmed to receive the wearing coat After the wearing coat is completed, similar sealant shall be provided to cover at least 50 mm on the wearing coat surface all-round the drainage assembly.

Drainage spouts shall be measured in **Nos.**

The contract unit rate for each drainage spout shall include the cost of all labour, material, tools and plant required for completing the work as per these Specifications. It shall also include the cost of providing flow drain pipes with all fixtures up to the point of ground drains wherever shown on the drawings.

Item No.27:- Providing, laying and jointing in true line and level 110 diameter U.P.V.C (Type B) conforming to IS 13592-1992 with one end plain and other end socketed with rubber ring, & fittings conforming to ISI 14735-1999 of approved make for drainage system pipe line, pipe shall be jointed with each other with rubber lubricant, pipe shall be fixed on wall using of PVC clamp of the size 110 mm diameter x 149 mm length x 145 mm height at every 2000 mm center to center or shall be concealed in walls as directed including necessary fittings such as bends, shoes etc. including testing of pipes and joints and jointed with adhesive solvent cement including cost of all materials. (For connecting all the water spouts at Flyover & Approach complete)

1.0. Materials

- 1.1.** The pipes shall be standard I.S.I. mark [U.P.V.C. SWR Type B pipe](#) of specified dia.
- 1.2.** The fittings, clamps etc. required for specified dia. bore pipes shall be of best quality and makes as approved by the Engineer-in-charge. Necessary accessories with inner/ outer brass thread shall be used as required and instruction by Engineer in charge.

2.0. Workmanship

2.1. Cutting, Laying & Jointing

- 2.1.1.** When the tubes are to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The ends of the tubes shall then be threaded conforming to the requirements of I.S. 554-1955 with pipe dies and taps carefully in such a manner that it will not result in slackness of joints when the two pieces are screwed together.
- 2.1.2.** The taps and dies shall be used only for straightening screw threads which have become bent or damaged and shall not be used for turning of the threads so as to make them slack as the latter procedure may not result in the water tight joint. The screw threads for tube and fitting shall be protected from edge until they are fitted.

2.1.3. In jointing the tubes, the inside of the socket and the screwed end of the tubes shall be oiled and smeared with white or red lead and wrapping around with a few turns of fine spun yarn round the screwed end of the tube. The end shall then be tightly screwed in the socket, tees, etc. with a pipe wrench. Care shall be taken that all times free from dust and dirt during fixing. But from the joints shall be removed after screwing. After laying the open ends of the pipes shall be temperately plugged to prevent access of water, soil, or any other foreign matter. Jointing shall be carried out with proper chemical adhesive material and allow to dry.

2.1.4. Any threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved anti-corrosive paint to prevent corrosion.

2.2. Fixing concealed to wall, ceiling & floors.

2.2.1. In case of fixing [concealed cement point to](#) walls or ceilings, these shall run on the surface of the wall, or ceiling (not in chase) unless otherwise specified. The fixing shall be done by means of standard pattern, holder clamps keeping the pipes about 15 mm. clear of the wall. When it is found necessary to pattern, holder clamps keeping the pipes about 15 mm. clear of the wall. When it is found necessary to conceal the pipes and when specified so, chasing may be adopted or pipe fixed in ducts or recesses etc. provided that there is sufficient space to work on the pipe with usual tools. The pipe shall not ordinarily be buried in walls or solid floors, where unavoidable, pipe may be buried for short distances provided that adequate protection is given against damage and where so required joints are not buried. Where required M.S. tube sleeve shall be fixed at a place a pipe is passed through a wall or floor for expansion and contraction and other movements. In case the pipe is embedded in walls or floors, it should be painted with anti-corrosive bitumastic paint of approved quality. The pipe should not come in contact with lime mortar or lime concrete

as the pipe is affected by lime. Under the floors, the pipe shall be laid in layer of sand filling.

2.2.2. All pipes and fittings shall be fixed truly vertical and horizontal unless unavoidable. The pipes shall be fixed to walls with standard pattern clamps of required size and shape, one end of which shall be properly plugged or cemented into walls with cement mortar 1:3 (1 cement : 3 coarse sand) and the other tightened round the pipes to hold it securely. These clamps shall be spaced at regular intervals in straight lengths at 2 MC/C interval in horizontal run and 2.5 m. interval in vertical run. For pipe of 15 mm. dia. up to 25 mm. dia the holes in the walls and floors shall be made by drilling with chisel or jumper and not by dismantling the brick work or concrete. However for bigger diameter pipes the holes shall be carefully made (1 cement : 3 coarse sand), and properly finished to match the adjacent surface.

2.3. Testing of joints :

2.3.1. After laying and jointing, the pipes and fillings shall be inspected under working conditions of pressure and flow. Any joints found liken shall be redone, and ail leaking pipes removed and replaced without extra cost.

2.3.2. The pipes and fittings after they are laid shall be tested to hydraulic pressure of 6 Kg./Sq cm. The pipe shall be slowly and carefully charged with water allowing all air to escape and avoiding all shocks and water hammer. The draw off takes and stop cock shall then be closed and specified hydraulic pressure shall be applied gradually. The pressure gauge must be accurate. The pipes and fittings shall be tested in sections as the work laying proceeds, keeping, the joints exposed for inspection during the testing.

3.0. Mode of measurements and payment

3.1. The description of the item shall, unless otherwise stated be held to include where necessary conveyance and delivery, handling, unloading, storing fabrication, hoisting, all labour for finishing to

required shape and size, setting, fitting in position straight, cutting and waste return of packing etc.

- 3.2.** The length shall be measured on **Rmt.** basis of finished work. The length shall be taken along the centre line of the pipe and fittings. The pipes fixed to wall, ceiling, floors etc shall be measured and paid under this item.
- 3.3.** All the work shall be measured in decimal system as fixed in its place, subject to tolerance given below unless otherwise stated.
- (i) Dimension shall be measured to the nearest 0.01 meter.
- (ii) Area shall be worked out to the nearest 0.01 sq. meter.
- 3.4.** All measurements of cutting shall unless otherwise stated be held to include the consequent waste.
- 3.5.** In case of fitting of unequal bore, the target bore shall be measured for the test.
- 3.6.** Testing of pipe lines fittings, and joints include for providing all plant appliances necessary for obtaining access to the work to be tested and carrying out the tests.
- 3.7.** The rate includes **U.P.V.C. SWR Type B pipe** with screwed socket joints to gather with all fittings (such as bends, sockets, springs, elbows, test crosses, short pieces, clamps and plugs, unions etc.) and fixing complete with clamping wall hooks, wooden plug etc. and also curing, screwing and waste and for making forged (or hand made) bends on piping as required. Connector shall be inserted where required or directed. The rate also includes cutting through walls, floors etc. and their making good and painting exposed threads with anti-corrosive paint as above and testing where tubes are to be fixed to wall, ceiling and flooring, the rates shall not include painting of pipes, providing sleeves and sand filling under floor for which separate payment shall be made.
- 3.8.** The rate shall be for a unit of one **Rmt.**

Item No.28:- Providing and laying - Filter Media 600mm thick directed at the back of abutments, returns and wing walls as per detailed specifications.

Well graded pebbled or metal of 40 mm. to 63 mm. size shall be used, the grading and tolerances of metal of pebbles shall be as under:-

Sr. No.	No. of Size Range	Sieve designation	Percentage by wight passing through the sieve
1.	63 mm to 40 mm	90 mm	100-00
		63 mm	85-100
		50 mm	35-70
		40 mm	00-15
		20 mm	00-05

The size shall be 40 mm. to 63 mm. where in tolerance limit for over size shall be upto 15% and that for lower size should be upto 15% and below 20 mm. it shall be allowable upto 5%. The filter Material shall be tightly placed to a thickness of not less that 600 mm. and provided over the entire surface behind abutments, wings or return walls to the full height as shown on drawing and as directed.

2. Materials shall be first stacked in boxe of 2 m. x 1.½ m. x 0.5 m. size on fairly level ground and measured for cross checking the adequacy of the quantity required.

3. The filter media behind abutment and return wall shall consist of three layers, the first layer of rubble of required size, the second layer of stone aggregates of 40 to 63 mm size and the third layer of coarse sand. The total thickness of the filter media shall not be less than 600mm as specified in the item.

4. The measurement for payment shall be made as finished work on **Sqm.** basis

5. The unit rate includes the cost of materials, scaffolding labour and tools to complete the work.

Item No.29:- Providing and casting in situ controlled cement concrete M-35 for approach slab including formwork curing and finishing complete.

This work shall consist of providing and casting in situ-controlled cement concrete M-35 grade for **approach slab** and shall be carried out as per relevant detailed specification of **Item No.4** of this contract.

The payment will be made on **Cu.m.** basis of the finished work.

Item No.30:- Providing and fixing in position FE 550D TMT bar reinforcement including cutting, bending and tying complete as per detailed drawings. (A) R.C.C. Kerb. (B) R.C.C. Footpath.(C) R.C.C. Approach slab.(D)Wearing Coat. and including Providing fusion bonded Epoxy coating not less than 175 micron thickness and up to 300 micron to reinforcement bars as per IS-13620-1993/ASTM-775 M including testing of coating at plant and all taxes.

This work shall consist of **Providing and fixing in position of steel grade FE 550 D WITH FBEC** for (A) R.C.C. Kerb. (B) R.C.C. Footpath.(C) R.C.C. Approach slab.(D)Wearing Coat. and shall be carried out as per relevant detailed specification of **Item No.16** of this contract.

The payment will be made on **M.T.** basis of the finished work.

Item No.31:- Providing and casting in situ controlled cement concrete M 40 for average 100 mm. thick wearing coat laid as directed including tamping vibrating finishing curing and filling in joints with bitumen complete.

This work shall consist of providing and casting in situ-controlled cement concrete **M 40 for average 100 mm. thick wearing coat** and shall be carried out as per relevant detailed specification of **Item No.4** of this contract.

The payment will be made on **Cu.m.** basis of the finished work.

Item No.32:- Providing and laying Pitching on slopes laid over prepared filter media including boulder apron laid dry in front of toe of embankment complete as per drawing and Technical specifications (A) Stone/Boulder

2504 PITCHING/REVETMENT ON SLOPES

2504.1 Description

The work shall consist of covering the river side slopes of guide bunds, training works and road embankments with stone, boulders, cement concrete blocks or stones in wire crates over a layer of granular material which will act as a filter. The rear slopes, not subjected to direct attack of the river, may be protected by 300 mm- 600 mm thick cover of clayey or silty earth and turfing.

2504.2 Pitching and Filter Medium

2504.2.1 Pitching

The pitching shall be provided with stones of thickness and shape as indicated on the drawings.

The stones shall be obtained from quarries and shall be sound, hard, durable and fairly regular in shape. Round boulders shall not be allowed. Stones showing marked deterioration by water or weather shall not be accepted.

The size and weight of stone shall conform to Clause 5.3.5.1 of IRC: 89. No stone, shall weigh less than 40 kg. The size of spalls shall be a minimum of 25 mm and shall be suitable to fill the voids in the pitching.

Where the stones of required size are not economically available, cement concrete blocks in minimum M15 grade concrete conforming to Section 1700 of these Specifications or stones in wire crates, shall be used.

Geosynthetics, if used in pitching, shall conform to Section 700 of these Specifications.

2504.2.2 Filter Medium

The material for the filter shall consist of coarse sand, gravel or stone. One or more layers of graded materials, to act as a filter medium, shall be provided

underneath the pitching, to prevent loss of the embankment material and build up of uplift head on the pitching.

The gradation of the filter material shall satisfy the following requirements:

$$\begin{array}{l} \text{D 15 (Filter)} \\ \text{-----} < 5 \\ \text{D 85 (Base)} \\ \\ \text{D 15 (Filter)} \\ 4 < \text{-----} < 20 \\ \text{D 15 (Base)} \\ \\ \text{D 50 (Filter)} \\ \text{-----} < 25 \\ \text{D 50 (Base)} \end{array}$$

Notes:

- 1) Filter design may not be required if embankment consists of CH or CL soils with liquid limit greater than 30, resistant to surface erosion. In this case, if a layer of material is used as bedding for pitching, it shall be well graded and its D 85 size shall be at least twice the maximum void size in pitching
- 2) In the foregoing, D 15 means the size of that sieve which allows 15 percent by weight of the filter material to pass through it and similar is the meaning of D 50 and D 85 (15 being replaced with 50 and 85 respectively).
- 3) If more than one filter layer is required, the same requirement as above shall be followed for each layer. The finer filter shall be considered as base material for selection of coarser filter.
- 4) The filter shall be compacted to a firm condition. The thickness of filter is generally of the order of 200 mm to 300 mm. Where filter is provided in two layers, thickness of each layer shall be 150 mm.

2504.3 Construction Operations

Before laying the pitching, the side of banks shall be trimmed to the required slope and profiles by means of lines and pegs at intervals of 3 m. Depressions shall be filled and thoroughly compacted.

The filter granular material shall be laid over the prepared base and compacted to the thickness specified on the drawings by means of suitable equipment.

The lowest course of pitching shall be started from the toe wall and built up in courses upwards. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Clause 1405.3, of these Specifications in case of dry rubble pitching. It shall be in nominal mix cement concrete (M 15) conforming to Clause 1704.3, of these Specifications in case of cement concrete block pitching.

The stone pitching shall commence in a trench below the toe of the slope. Stone shall be placed by derrick or by hand to the required length, thickness and depth conforming to the drawings. Stones shall be set normal to the slope, and placed so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of pitching.

The largest stones shall be placed in the bottom courses and for use as headers for subsequent courses.

In hand placed pitching, the stone of flat stratified nature should be placed with the principal bedding plane normal to the slope. The pattern of laying shall be such that the joints are broken and voids are minimum by packing with spalls, wherever necessary, and the top surface is as smooth as possible.

When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices between adjacent stones shall be filled in with spalls of the proper size wedged in with hammers to ensure tight packing.

When two or more layers of stones must be laid to obtain the design thickness of pitching, dry masonry shall be used and stones shall be well bonded. To ensure regular and orderly disposition of the full intended quantity of stone as shown, template cross walls in dry masonry shall be built about a metre wide and to the full height of the specified thickness at suitable intervals all along the length and width of the pitching. Within these walls the stones shall be hand packed as specified.

2504.4 Toe Protection

A toe wall shall be provided at the junction of slope pitching and launching apron of a guide bund so as to prevent the slope pitching from sliding down. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Section 1400 of these Specifications or in cement concrete of M 15 grade. The pitching/revetment shall be of stones in wire crates or cement concrete blocks in M15 grade. For protection of ties of bank slopes terminating either in short aprons at bed levels or anchored in flooring/rocky bed, the provision of Clause 8.2.2 of IRC:89 may be complied with.

2509 MEASUREMENTS FOR PAYMENT

The earth work in construction of embankment for guide bund shall be measured in **cubic metres** unless otherwise specified.

The boulders/cement concrete block and boulder/block filled wire crates in apron shall be measured in cubic metres.

The filter and stone pitching shall be measured separately in cubic metres unless otherwise specified.

Rubble stone/cement concrete block flooring and cement concrete bedding shall be measured in cubic metres for each class of material.

Preparation of base for laying the flooring shall be deemed incidental to the work.

For laying apron, excavation upto an average depth of 150 mm shall be deemed to be included in the main item and shall not be measured separately unless otherwise specified. Excavation more than 150 mm shall be measured in cubic metres as per Section 300 of these Specifications.

If directed by the Engineer, the materials shall have to be stacked at site before laying and such stacking shall be considered incidental to the work.

2510 RATE

The contract unit rate for the construction of embankment for guide bund shall cover the cost of all materials including transportation, laying, compacting, all

labour, tools, equipment, sampling and testing, supervision and all incidentals necessary for completing the work according to these Specifications.

The contract unit rate for apron shall include the cost of all material, labour, tools and plant for completing the work according to these Specifications. Excavation up to an average depth of 150 mm shall also be deemed to be included in the rate as dressing of the bed. Excavation beyond the depth of 150 mm shall be paid for separately unless otherwise specified.

The contract unit rate for stone/cement concrete block pitching on slopes shall include the cost of preparing the bases, laying and compacting the filter and placing of stone pitching of dry rubble/cement concrete block revetment for embankment slopes to the specified thickness, lines, curves, slopes and levels and all labour and materials as well as tools and plant required for the work.

The contract unit rate for rubble stone/cement concrete block flooring shall include the cost of all material, labour and tools and plant for completing the work as per specifications for the relevant item.

Item No.33:- Providing and laying Filter material underneath pitching in slopes complete as per drawing and Technical specification

This work shall consist of Providing and laying Filter material underneath pitching in slopes and shall be carried out as per relevant detailed specification of **Item No.32** of this contract.

The item shall be measured & paid as finished work in **Cum**.

Item No.34:- Filling available excavated earth (excluding rock) in trenches. plinth, sides of foundations etc. in layers not exceeding 20 cm. in depth consolidating each disposed layer by ramming and watering.

WORKMANSHIP

- 1.1. The earth to be used for filling shall be free from salts, organic or other foreign matter all clots of earth shall be broken.
- 1.2. As soon as the work in foundation has been completed and measured the site of foundation shall be cleared of all debris brick bats mortar

dropping etc. and filled with earth in layers not exceeding 20 cms. each layer shall be adequately watered, rammed and consolidated before the succeeding layer is laid. The earth shall be rammed with iron rammers where feasible and with the ends of crow-bars, where rammer cannot be used.

1.3 The foundation shall be similarly filled with earth in layers not exceeding 20 cms adequately watered and consolidated by ramming with iron or wooden rammers. When filling reaches finished level the surface shall be flooded with water for at least 24 hours and allowed to dry and then rammed and consolidated.

1.4 The finished level of filling shall be kept to shape intended to be given to shape.

1.5 In case of large area the consolidation may be done by power rollers, where so specified. The extent of consolidation required shall also be as specified.

2.0. Mode of Measurements & Payment

2.1. The payment shall be made for filling in plinth and trenches. No deduction shall be made for shrinkage or voids, if consolidated as instructed above.

2.2. The rate shall be for a unit of one **Cum.**

Item No.35:- Finishing wall with weather proof exterior emulsion paint on wall surface (two coats) to give an required shape even shade after thoroughly brushing the surface to remove all dirt, and remains of loose powdered materials.etc complete (On exposed surfaces of Pier/Abutment/Pier Cap/Deck Slab/RE Wall etc.)

General

This work shall consist of painting the walls with exterior emulsion paint of the shape and dimensions shown on the drawings and conforming to these Specifications or as approved by the Engineer in charge.

MATERIALS

1.0 Exterior Emulsion Paint

Exterior emulsion paint shall be of specified colour as approved by Engineer in charge the ready mixed exterior emulsion paint shall not be allowed, If however ready mix exterior emulsion paint of specified shade or tint is not available white ready mixed paint with approved Steiner will be allowed in such case the contractor shall ensure that the shade of the paint so allowed shall be uniform exterior emulsion paint shall meet with the following general requirements

1. exterior emulsion paint shall not show excessive setting in freshly opened full can and shall easily be redispersed with a paddle to a smooth homogeneous state. The exterior emulsion paint shall show no curding, livering cracking or colour separation and shall be free from lumps and skins.
2. The exterior emulsion paint as received shall brush easily possess good leveling properties and show no running or sagging tendencies.
3. The exterior emulsion paint shall not skin within 48 hours in a three quarters filled closed container
4. The exterior emulsion paint shall dry to a smooth uniform finish free from roughness grit unevenness and other imperfections
5. Ready mix exterior emulsion paint if allowed for specified shade, shall be used exactly as received from the manufacturers and generally according to their instruction and without any admixtures whatsoever.

2.0 WORKMAN SHIP

2.1 Scaffolding:

Where scaffolding is required, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be distempered. A properly secured strong and well tied suspended platform (joola) may be used for distempering. Where ladders are used, pieces of old gunny bags

3.0 Application coat:

The exterior emulsion paint shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer only. Sufficient quantity of distemper required for a day's work shall be prepared.

3.1 For undecorated surfaces, after the primer coat is dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the exterior emulsion paint, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. Minimum two coats of the exterior emulsion paint shall be applied with brushes in horizontal strokes followed immediately by vertical strokes which together shall constitute one coat. The subsequent coats shall be applied after a time interval of at least 24 hours between consecutive coats to permit proper drying of the preceding coat. The finished surface shall be even and uniform without patches, brush marks, distemper drops etc.

3.2 Sufficient quantity of the exterior emulsion paint shall be mixed to finish one room at a time.

4.0 MODE OF MEASUREMENT & PAYMENT:

4.1. The unit rate wall painting with exterior emulsion paint shall include the cost of all materials, tools and plant required for mixing, cleaning brushing sand papering & painting with all required specials and Lapi compound, finishing as per direction of the Engineer-in-charge, and all other incidental expenses for producing pipe line work of specified diameter to complete the structure or its components as shown on the drawings and according to these specifications. They shall also include the cost of making, fixing and removing of all scaffolding and forms required for the work.

4.2 The rate of Wall painting with exterior emulsion paint shall include the cost of all labour, materials tools and plant scaffolding and all incidental expenses as described herein above.

4.3. The Wall painting with exterior emulsion paint shall be measured for its length and Height limiting dimensions to those specified on plan or as directed. The rate shall be for a unit of one square meter.

4.4. The payment will be made on **Square Meter**. basis of the finished work.

Item No.36:- Carryout soil investigation work including drilling 150 mm dia bore holes in all sorts of soil, ordinary rock and hard rock, upto maximum depth as mentioned, collection undisturbed samples and conduction standard penetration tests alternate at an interval of 1.5 to 2.0 m depth, conducting necessary laboratory tests for all type of classification and determination of soil parameters like density, shear and consolidation parameters if required, including submission of report in three copies covering investigation data and recommendation for SBC & and pile capacity considering the design criteria, all as per specification.

Soil Investigation (Soft Soil)

Soil Investigation (Soft Soil) as per (IS:2720 Part 1-41) and as per instruction by engineer in charge.

1. Scope of Work

The Consultant shall carry out **comprehensive soil investigation for soft soil conditions** along the highway corridor, including:

- Borehole / Trial Pit Exploration Determination of **soil profile, groundwater level, and soil type**
- Boreholes to be drilled to the **design depth or as instructed by Engineer-in-Charge**
- Sampling of Soils Disturbed and undisturbed samples for laboratory testing
- Collection at **regular intervals and at significant strata changes**
- Field and Laboratory Tests Standard penetration tests (SPT) / Cone Penetration Test (CPT)
- In-situ density, moisture content, and permeability
- Laboratory tests on strength, compressibility, and consolidation
- Preparation of Report Soil stratigraphy, properties, bearing capacity, and settlement characteristics
- Recommendations for **pavement subgrade, embankments, and foundation design**

Exclusions:

- Ground improvement or construction activities (unless instructed)

2. Applicable Standards

IS 2720 (Part 1–41) – Methods of Test for Soils Part 1: Preparation and Sampling

Part 2: Determination of Moisture Content

Part 3: Determination of Specific Gravity

Part 4: Grain Size Analysis

Part 5: Atterberg Limits

Part 6: Compaction Test

Part 7: Water Content-Dry Density Relation

Part 10: Determination of California Bearing Ratio (CBR)

Part 11: Determination of Free Swell Index

Part 14: Consolidation Test

Part 15: Shear Strength (Direct Shear / Triaxial)

Part 19: Permeability Test

Part 41: Soil Exploration and Sampling Guidelines

IRC:37-2012 / IRC:58-2015 – Subgrade evaluation for flexible and rigid pavements

MoRTH / State PWD Guidelines – Highway soil investigation

3. Test Methodology

3.1 Field Investigation

- **Borehole / Trial Pit Spacing:** As instructed by Engineer, generally 200–500 m for highways

- **Depth:** Up to design subgrade level + 2 m or as instructed

In-situ Tests: SPT / CPT for soil strength and stratigraphy

Groundwater table measurement

Field density by core cutter or sand replacement method

3.2 Laboratory Testing

- **Moisture content** (IS 2720 Part 2)

- **Specific gravity** (IS 2720 Part 3)

- **Grain size analysis** (Part 4)

- **Atterberg limits** (Part 5)

- **Compaction / Proctor test** (Part 6 / 7)

- **CBR test** (Part 10)

- **Consolidation test** (Part 14)

- **Shear strength** (Direct shear / Triaxial, Part 15)

- **Permeability** (Part 19)

3.3 Reporting

- Soil profile with **layer thickness, type, and properties**

- Groundwater table data and seasonal variation
- Recommendations for **pavement subgrade, embankment design, and soft soil treatment**

4. Quality Requirements

- Boreholes and pits properly **cased and supported** to prevent collapse
- Samples **undisturbed where required** for consolidation and shear tests
- Laboratory tests conducted by **ISO/ NABL accredited labs**
- All measurements recorded with **accuracy within IS specified tolerances**
- Chainage, depth, and soil type clearly documented

5. Deliverables

- Soil Investigation Report Borehole log with soil description and depth
- Field and laboratory test results
- Soil classification, strength, and compressibility parameters
- Recommendations Subgrade preparation
- Soft soil stabilization / treatment if required
- Pavement and embankment design considerations
- Digital Data Borehole log sheets, test results in spreadsheet / CAD format

Mode of Payment

- Payment shall be made on per Rmt **basis** (as specified in BOQ)

Item No.37:- Providing and fixing post and pipe railing as per detailed drawing including 3 coats of painting to steel works complete.

1.G.L. Pipes shall be of light duty type. Concrete shall conform to relevant specifications of item of concrete of ordinary grade specified in the item. For structural steel relevant specifications of item of steel cutting edge and for mild steel, relevant specifications of item of M.S. reinforcement shall apply.

2 The pipe railing shall consist of R.C.C. posts required dimensions as approved by the Engineer-in-charge or structural steel sections as shown on the drawings. The structural section shall be anchored to RCC in the manner as directed by the Engineer-in-charge. Three rows of G.I. pipe, upper one of 50 mm. dia, and lower two of 40 mm. diameter shall be provided. Holes of required' size shall be made in the posts and the pipe shall be fixed with necessary couplings and three coats of enamel paint shall be applied to iron work (first coat shall be of red lead) If R.C.C. posts are used they shall be applied 2 coats of white wash. The posts shall be fixed at 2 m. to 2.5 m. centre to centre depending upon the span length.

4. Railing shall be measured **Rmt.**
5. Unit rate includes cost of all materials, labour, tools and plant to complete the job.

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